SCIENTIFIC RESEARCH AT THE SMITHSONIAN—MORE THAN A MUSEUM

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

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SCIENTIFIC RESEARCH AT THE SMITHSONIAN—MORE THAN A MUSEUM

TUESDAY, JANUARY 14, 2014

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 2:29 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Larry Bucshon [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
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Subcommittee on Research and Technology

Scientific Research at the Smithsonian - More than a Museum

Tuesday, January 14, 2014
2:00 p.m. to 4:00 p.m.
2318 Rayburn House Office Building

Witnesses

Dr. G. Wayne Clough, Secretary, Smithsonian Institution

Dr. Eva Pell, Under Secretary for Science, Smithsonian Institution

Dr. Kirk Johnson, Director, National Museum of Natural History

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

HEARING CHARTER

Scientific Research at the Smithsonian - More than a Museum
Tuesday, January 14, 2014
2:00 p.m. - 3:30 p.m.
2318 Rayburn House Office Building

Purpose

On January 14th, the Research and Technology Subcommittee will hold a hearing to examine the Smithsonian Institution's scientific research activities. In addition the management and scientific preservation techniques of museum collections will be discussed.

Witnesses

- **Dr. G. Wayne Clough,** Secretary, Smithsonian Institution
- **Dr. Eva J. Pell,** Under Secretary for Science, Smithsonian Institution
- **Dr. Kirk Johnson**, Director, National Museum of Natural History

Background

The Smithsonian is the largest museum and research complex in the world. The Smithsonian Institution (SI) was founded in 1846 by the United States Congress in response to a bequest of $500,000 by British scientist James Smithson, donated "to the United States of America, to found at Washington, an establishment for the increase and diffusion of knowledge among men." The original Smithsonian 'Castle' contained a library, lecture halls, exhibits and demonstrations, laboratories, and scientific artifact collections. In the past 168 years, SI has expanded to include 19 museums and galleries and nine research facilities. Over 180 museums around the country are now affiliated with the Smithsonian. SI employs over 6,000 people and has as many volunteers, and publishes *Smithsonian* and *Air & Space* magazines in addition to scholarly works. The Smithsonian collections include over 137 million objects, and specimens, 1.8 million library volumes, and more than 164,000 cubic feet of archival material. In 2013, SI museums and the National Zoo welcomed nearly 31 million visitors, while the 270 Smithsonian websites had over 140 million unique visitors.

Governance and Oversight

Originally established by an Act of Congress, the Smithsonian is technically a 'trust instrumentality' of the federal government and is not part of the executive branch. The 17-member Board of Regents acts as the Smithsonian's governing body. Traditionally, the Chief Justice of the United States is elected Chancellor, with the Vice President and Chief Justice both serving as ex-officio members of the Board. The rest of the board is composed of three Members each from the House and Senate, and nine citizen members authorized by a joint

resolution of Congress. The Secretary is elected by the Board, as are the members of the Executive Committee. Dr. G. Wayne Clough has served as the secretary since July 2008.

Funding

Smithsonian has an annual operating budget of more than $1 billion, of which approximately 70% comes from direct federal appropriations. Smithsonian's Fiscal Year (FY) 2014 request for Congressional appropriations totals $890 million. Congressional Appropriations for FY 2013 was $775 million. Of this, approximately $93 million annually is devoted to research[1]. The remainder is held in general trust funds, separate from federal appropriations in SI's own budget, including revenue from the museums, publication sales, licensing, private donations, and from both federal and non-federal grants and contracts. More than half of the total budget is allocated to salaries and benefits for Smithsonian employees, including researchers and scientists directly employed by the Institution. The Institution is a 501(c)(3) tax-exempt non-profit organization.

Research

In the early years of the Smithsonian Institution, its focus was largely on science itself. Its first Secretary, American scientist Joseph Henry, focused on research and the "increase of knowledge" rather than its "diffusion," and was relatively unenthusiastic about museums. Today, the SI is a recognized leader in many areas of scientific research, and houses some of the largest and most acclaimed research programs in their respective fields. The SI mission focuses on broadening access, revitalizing education, crossing boundaries, strengthening collections, organizational excellence and measuring performance. Although the Institution has evolved to have a strong focus on cultural and historic knowledge as well, the first two of its "Grand Challenges" are directly related to scientific discovery and understanding. These Challenges are: "*Unlocking the Mysteries of the Universe*" and "*Understanding and Sustaining a Biodiverse Planet*".

The science-based research centers, as well as several of the Smithsonian's museums and the National Zoo, are overseen by the Smithsonian's Under Secretary for Science, a post currently held by Dr. Eva Pell, while other museums and programs fall under the Under Secretary for History, Art, and Culture. The Smithsonian's science-based research centers include the following: Center for Earth and Planetary Studies (CEPS) at the National Air and Space Museum (NASM), Smithsonian Conservation Biology Institute (SCBI) an outpost of the National Zoological Park (NZP), Smithsonian Environmental Research Center (SERC), Smithsonian Astrophysics Observatory (SAO) which together with Harvard makes up the Harvard-Smithsonian Center for Astrophysics (CfA), Museum Conservation Institute (MCI), National Museum of Natural History (NMNH), and the Tropical Research Institute (STRI)

In many cases, Smithsonian scientists also compete for research funding from other federal grant–making agencies, including NASA, NIH, NSF, and the Department of Defense, or private grant-making organizations.

[1] http://www.whitehouse.gov/sites/default/files/omb/budget/fy2014/assets/oia.pdf

Scientific Collections

The Smithsonian also has the one of the largest federal object-based scientific collections, serving as a resource for Smithsonian's own research and museum display purposes and for other federal and academic scientists as well. The Institution's natural history collection is the largest in the world, approximately 137 million total specimens collected. The Smithsonian is working to digitize much of its collection. Thus far, more than 8.5 million records and nearly one million images are available to the public via the Smithsonian's website. The Smithsonian's websites receive eight times as many "visitors" as its museums, making digitization of Smithsonian collections an integral part of SI's greater education and outreach initiatives.

Other federal departments and agencies also have large scientific collections, such as United State Department of Agriculture (USDA)'s collections of plants, diseases, and other agriculture-related specimens, or National Institute of Standards and Technology (NIST)'s calibration collections, used to define and calculate accurate weights and measurements. Some of the Smithsonian's own collections are also shared or maintained with other agencies; USDA's parasite collection now housed at NMNH is one of the most recent examples. In addition to USDA, Department of Defense (DoD), National Oceanic and Atmospheric Administration (NOAA), and United States Geological Survey (USGS) have partnered with NMNH in jointly maintaining parts of the national collection. The Smithsonian is believed to have the most individual specimens and artifacts of any collection in the world.

Chairman BUCSHON. All right. The Subcommittee on Research and Technology will come to order.

Good afternoon, everyone. Welcome to today's hearing entitled "Scientific Research at the Smithsonian." In front of you are packets containing the written testimony, biographies, and truth-in-testimony disclosures for today's witnesses. I now recognize myself for five minutes for an opening statement.

Founded in 1846, the Smithsonian is the world's largest museum and research complex, consisting of 19 museums and galleries, the National Zoological Park, and nine research facilities. In addition, the Smithsonian Institution houses 137 million objects—and probably increasing every day—artworks, and specimens. The Institution has been busy digitizing its records, with 8.45 million records currently available online. In 2013, 31 million people visited Smithsonian museums and there were over 102 million visits to its website.

However, the Smithsonian Institution is more than a museum; it is home to nine research centers and numerous research programs, which range from astronomy to marine biodiversity and ecosystems of Florida to understanding tropical biodiversity. Today's hearing will focus on the world-class scientific research activities at the Smithsonian Institution.

In 2013, the Smithsonian's Submillimeter Array peered through the galaxy to provide the first clear view of W49A, a stellar nursery where star formation takes place, revealing a giant star cluster in the making. In another finding, a team of Smithsonian scientists further explored overlooked preserved museum specimens. The journey that started at a museum in Chicago led to the cloud forests of Ecuador in the Northern Andes and back to the genetics labs in Washington, D.C., ending in the discovery of the olinguito, the first carnivorous mammal species discovered in the Americas in 35 years. This discovery was one of the top science stories of 2013. In other research, the first wild horse species was born from artificial insemination at the Smithsonian Conservation Biology Institute. These are a few of the research highlights being done that we will hear about during today's hearing.

In its 168-year history, the Smithsonian has inspired millions of Americans, and also given us the opportunity to learn about our Nation's history, culture, and values. At the same time, it is important that the Smithsonian focus its resources on research that will maintain its world-class status and will allow its researchers to solve problems that are vital to the national interest.

Our witnesses today will display and have displayed some of the important research activities that are ongoing at the Smithsonian and will provide a vision for future activities. I look forward to hearing from our distinguished witnesses and having a productive discussion.

[The prepared statement of Mr. Bucshon follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
CHAIRMAN LARRY BUCSHON

Founded in 1846, the Smithsonian is the world's largest museum and research complex, consisting of 19 museums and galleries, the National Zoological Park, and nine research facilities. In addition, the Smithsonian Institution houses 137 million

objects, artworks, and specimens. The Institution has been busy digitizing its records, with 8.45 million records currently available online. In 2013, 31 million people visited Smithsonian museums and there were over 102 million visits to its website.

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This discovery was one of the top science stories of 2013. In other research, the first wild horse species was born from artificial insemination at the Smithsonian Conservation Biology Institute. These are a few highlights among the research being done that we will hear about during today's hearing.

In its 168 year history, the Smithsonian has inspired millions of Americans, and also given us the opportunity to learn about our nation's history, culture and values. At the same time, it is important that the Smithsonian focus its resources on research that will maintain its world-class status and will allow its researchers to solve problems that are vital to the national interest.

Our witnesses today will display some of the important research activities that are on-going at the Smithsonian, and will provide a vision for future activities. I look forward to hearing from our distinguished witnesses and having a productive discussion.

Chairman BUCSHON. With that, I will now recognize the Ranking Member, Mr. Lipinski from Illinois, for his opening statement.

Mr. LIPINSKI. Thank you, Mr. Chairman. I want to thank the distinguished witnesses who will testify here today.

Many of us remember school field trips and family outings to local museums, zoos, and aquaria, and you only have to visit the National Mall on any given weekend to see droves of young kids and families in line to see a range of Smithsonian exhibits. From the full skeleton of a Stegosaurus at the Museum of Natural History, to the command module of the Apollo 11 Moon landing at the Air and Space Museum, and a little further northwest, Bao Bao, the giant panda cub at the National Zoo who has gotten so much attention. I have to say, for not the Smithsonian so much, but going to museums and zoos back home were certainly important to me as a kid.

So for young people, the Smithsonian, thousands of museums and other science centers around the country, find some of the earliest exposures they have to science and some of the things that really hook many of them into an interest in science.

We heard a few years ago from the Chicago Zoological Society's Brookfield Zoo about their informal education programs and the important role they play in my own community. I am co-chair of the Congressional Zoo and Aquarium Caucus and have long been an advocate of the important role of museums, science centers, zoos, and aquaria, and informal science ed.

This Committee held a hearing last June to hear more about the Administration's proposal for the Smithsonian to take on new leadership in federal efforts on informal STEM education. While the Smithsonian has an impressive track record in providing informal education, it doesn't do everything that other science agencies now do. For example, unlike NSF, the Smithsonian does not make grants to external organizations including science centers and museums across the country. I am interested in hearing how the Smithsonian in its proposed new role would strengthen the partnerships it has with its 184 affiliate museums and how these local organizations and communities they serve will continue to benefit from their long-standing partnership with the federal government.

In addition to the opportunities it provides as a collection of museums and centers of science education, the Smithsonian is also a leading research institution, as Chairman Bucshon mentioned. The scientists at the Smithsonian's research centers conduct research on many topics of today's most interesting and important science from species preservation to climate change.

The Smithsonian collections also allow great science to take place and allow millions of visitors a firsthand glimpse of our national history. However, if these collections are not preserved, all this work could be lost. This Committee included a provision in the 2010 *America COMPETES* reauthorization requiring OSTP to develop consistent policies for the management and disposal of federal scientific collections and ensure development of an online clearinghouse for information on federal scientific collections. The Smithsonian is a natural leader among federal agencies in this effort along with the U.S. Department of Agriculture with a significant collection of its own. I am interested in hearing from the panel

what means are being taken to preserve these artifacts and digitize them so that they can be studied and viewed for generations to come.

And finally, the way the Smithsonian is funded is somewhat unique since it receives around $800 million annually in federal appropriations in addition to its many sources of private funds. But as everyone knows, we have been in a reduced budget environment, which the Smithsonian has not escaped. The American people also have slimmer checkbooks, and as such, may not be donating in the amounts that they have in the past. I would be very interested in hearing how the Smithsonian is prioritizing their research and what challenges they have faced during the last few years of budget cutting.

Again, I want to thank Chairman Bucshon for calling this hearing and the witnesses as well for being here. I look forward to your testimony and a productive discussion. With that, I yield back.

[The prepared statement of Mr. Lipinski follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
RANKING MINORITY MEMBER DANIEL LIPINSKI

Thank you Mr. Chairman for holding this hearing, and thank you to the distinguished witnesses who are testifying.

Many of us remember school field trips and family outings to local museums, zoos, and aquaria, and you only have to visit the National Mall on any given weekend to see droves of young kids and families in line to see a range of Smithsonian exhibits; from the full skeleton of a stegosaurus at the Museum of Natural History, to the command module of the Apollo 11 Moon landing at the Air and Space Museum, and—a little further northwest—Bao Bao, the giant panda cub at the National Zoo. For many young people, the Smithsonian and the thousands of museums and other science centers around the country provide some of the earliest exposures they have to science. We heard a few years ago from the Chicago Zoological Society's Brookfield Zoo about their informal education programs and the important role they play in my own community. I am a co-chair of the Congressional Zoo and Aquarium Caucus and have long been an advocate of the important role of museums, science centers, zoos, and aquaria in informal science education.

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Again, I want to thank Chairman Bucshon for calling this hearing, and the witnesses as well for being here. I look forward to your testimony and a productive discussion.And with that I yield back.

Chairman BUCSHON. Thank you very much.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

Chairman BUCSHON. At this time I would like to introduce our witnesses. Our first witness today is Dr. G. Wayne Clough, and he currently is the 12th Secretary of the Smithsonian Institution. Since he began as Secretary in July 2008, Dr. Clough has overseen several major openings at the Smithsonian, including the reopening of the National Museum of American History, the David H. Koch Hall of Human Origins and Sant Ocean Hall at the National Museum of Natural History. Before his appointment to the Smithsonian, Dr. Clough was President of the Georgia Institute of Technology for 14 years. He received his bachelor's and master's degree in civil engineering from Georgia Tech and a doctorate in civil engineering from the University of California at Berkeley. Dr. Clough will be retiring later this year as the Secretary of the Smithsonian. I would like to take this opportunity to thank you for your hard work these past six years and wish you well in future endeavors.

Our second witness today is Dr. Eva Pell. As Under Secretary for Science at the Smithsonian Institution, Dr. Pell directly overseas the operations of several museums, including the National Museum Of Natural History, the National Air and Space Museum, the National Zoo and its Conservation and Research Center in Front Royal, Virginia, and the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts. Do you have time for all that?

Dr. Pell was a Professor in the Department of Plant Pathology at Penn State University for more than 35 years. In her role as Senior Vice President for Research at the university, Dr. Pell spearheaded the development of cross disciplinary institutes for life sciences, materials, energy, and environment, social sciences, cyber science, and the arts and humanities. Dr. Pell earned her BS in biology from the City College of the City of New York and a Ph.D. in plant biology from Rutgers. Thank you.

Our third witness today is Dr. Kirk Johnson, who is currently the Sant Director of the National Museum of Natural History and was appointed to this position in October of 2012. In his previous position as Chief Curator at the Denver Museum of Nature and Science, Dr. Johnson oversaw a 70-person Research and Collections Division. From 2001 to 2006 Dr. Johnson was the Chair of the museum's Department of Earth Sciences. Between 1991 and 1995 he was one of the two scientists who led the development of Prehistoric Journey, the museum's permanent exhibition about the history of life on Earth. From 1989 to 1990 he was a postdoctoral research associate in the Department of Botany at the University of Adelaide in Australia. He was a marine geologist with the U.S. Geological Survey in California from 1982 to 1983 and has been a research associate at the Burke Museum of Natural History and Culture in Seattle since 1991.

Thanks again to all our witnesses for being here this afternoon. As our witnesses should know, spoken testimony is limited to five minutes each, after which the Members of the Committee will have five minutes each to ask questions.

I now recognize Secretary Clough for five minutes to present his testimony. Welcome, sir.

TESTIMONY OF DR. G. WAYNE CLOUGH, SECRETARY, SMITHSONIAN INSTITUTION

Dr. CLOUGH. Thank you, Mr. Chairman, and thank you for this opportunity to testify.

I was last here in 2010 and at that time we were in the early stages of implementing our new strategic plan. Since then, we have made considerable progress towards all of our goals and much of this relates to our science museums and our research centers.

Many of you just saw compelling evidence of that progress if you were able to visit with our staff members here. I am extremely proud of our 500 scientists at the Smithsonian and what they do to help us understand our world, our universe, and enable us to create a sustainable future for future generations. The scientists you just met demonstrate the passion all of our employees at the Smithsonian have, and that is why for the past four years we have been named as one of the best places to work in the federal government.

The Smithsonian, as was mentioned, is a public-private partnership. Roughly 60 percent of our funding comes from federal appropriations and 40 percent from other sources. We have worked hard over the past five years to enhance our private funding and use it in a way that best complements the federal funding that we receive. With our strategic plan as a guide, we have attracted increased support from donors and funding agencies to make progress we would not have imagined a decade ago.

Last year, 31 million visits were made to our museums, the best attendance we have had in a decade. For the millions who could not visit, we are doing more than ever to reach them through our traveling exhibition service, our 184 affiliate museums, and digital technology. More than 140 million unique visitors used our websites last year. We are now delivering education materials geared to state standards to all 50 States. This is a passion of mine because I am an educator. I was raised in a family of modest means in a small rural town of Douglas, Georgia. I didn't experience the Smithsonian until I went to college. Our strategic plan documents our commitment to ensure people in any part of our Nation can access our resources, and we are working hard to deliver on that promise.

As noted, we were founded in 1846, and the Smithsonian is the world's largest museum and research complex with 19 museums and galleries, the National Zoo, nine research centers, and 20 libraries and archives. As noted, we have 137 million objects in our collections and 127 million of these are scientific objects, some of which you have seen here. We are active in more than 130 countries through our research and education efforts. Last year, we had more than 3.8 million social media followers on Facebook and Twitter. The Smithsonian Channel now reaches 30 million people and families and households, up from 6 million five years ago.

Under our strategic plan our activities are organized to focus on four grand challenges, two of which are focused on science. The first is understanding and sustaining a biodiverse planet. The sec-

ond is unlocking the mysteries of our universe. The plan also calls, one, for greater emphasis on cross disciplinary research and collaboration and cooperation with other science-based federal agencies, universities, nonprofits, and industry; two, increase science-based educational offerings; and three, improved attention to care of collections.

Our collaborative and cross disciplinary approach is exemplified by something we call the Forest Global Earth Observatory, a network of more than 50 sites around the world where long-term standardized observations of forest changes are made. The data are organized and stored digitally so all scientists around the world and teachers and students can use the information. More than 20 countries, nine U.S. universities, and the U.S. Forest Service participate with us in this effort.

And thanks to a generous donor, we have recently launched the Tennenbaum Marine Observatories Network, which will perform a similar monitoring task to the forest effort in our coastal waters. As the partnership expands, many other universities and science agencies will join our initiative. Our scientific research forms the basis for educational resources offered in digital online lesson plans. We also offer direct assistance to school districts through the Smithsonian Science Education Center. For 28 years, the center's innovative STEM program has been improving the K–12 science education in our nation, and in 2011, it won a highly competitive i3 innovation grant from the U.S. Department of Education to work with school districts in New Mexico, Texas, and North Carolina serving approximately 90,000 students, most of whom fall in the Title I classification. Assessments of this work have shown it to be extremely successful and more will come from this work since we are expanding it to workforce education.

As I look back over the past five years, I am proud that our scientific efforts have made a difference and we are positioned to do even more. As an educator, I am also proud of the fact we have increased participation of interns and fellows. Last year, we had more than 1,300 interns and 700 fellows working at the Smithsonian. And though we don't offer degrees, we help educate the scientific workforce of the future. Of course we also continue in what we do best, and that is inspire young people to learn more about science and our world.

You may have heard of high school junior Jack Andraka from Maryland who devised an inexpensive and quick test for pancreatic cancer after his uncle died of that disease. For that, in 2012 we presented him with our American Ingenuity Award for youth achievement. As a young boy, he was inspired by coming to the National History Museum. That is the power of science, to change the world with ideas and make it a better place and that is what we do best at Smithsonian.

[The prepared statement of Dr. Clough follows:]

U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Research and Technology
Testimony of Dr. G. Wayne Clough
Secretary, Smithsonian Institution
14 January 2014

Mr. Chairman and Members of the Committee, it is my privilege to again appear before the Subcommittee on Research and Technology to testify about the science research and education programs at the Smithsonian Institution. I am pleased to have this opportunity to update the Subcommittee on our progress in focusing and advancing our efforts since I testified in 2010. I am also eager to share with the new members of the Subcommittee how Smithsonian scientists are working to better understand the world around us and the ways the Smithsonian is sharing that knowledge with the American people and scholars around the world—as it has since its creation.

In August 1846, Congress passed legislation that founded the Smithsonian Institution as an establishment dedicated to the "increase and diffusion of knowledge." The legislation established the Smithsonian as a repository for the U.S. government's collections of "all objects of art and of foreign and curious research, and all objects of natural history, plants, and geological and mineralogical specimens." Indeed, the first objects donated to the Smithsonian were scientific apparatus.

Today the Smithsonian is the world's largest museum and research complex with 19 museums and galleries, the National Zoo, and nine research centers. Smithsonian Institution Libraries, which unites 20 libraries, is the most comprehensive museum library system in the world, supporting the vital research of the Smithsonian, as well as the work of scientists and scholars from around the world. Smithsonian collections total 137 million objects and specimens, including 127 million scientific specimens and more than 2,000 live animals at the National Zoo, more than 8.7 million historical artifacts, and more than 340,000 works of art, as well as 1.8 million library volumes and 164,000 cubic feet of archival material. We are home to 6,500 dedicated employees and 6,200 loyal volunteers. We are active in more than 130 countries. Last year we had more than 31 million visits as well as 3.8 million social media followers on Facebook and Twitter alone. The Smithsonian, with the support of the Administration, the Congress, the American people and generous donors, is a public-private partnership that is working incredibly well.

Seeking answers has always been in the Smithsonian's DNA. We look to the recent and ancient past, geological, anthropological, botanical, and zoological. We peer into the outer reaches of the universe and the most extreme depths of the oceans. We look at cultures across the globe and here at home. We examine brush strokes on canvas, clay on armatures, and pixels on screens. Through it all, our experts use our collections to ask questions and find answers to some of the world's most complex and pressing problems.

The Strategic Plan Focus on Grand Challenges for Science

When I last appeared before the committee, the Smithsonian had just begun implementing a new strategic plan, the first in its history, formulated with the input of many people inside and outside the Institution. It called for us to develop a new cross-disciplinary approach to the way we do our work, to seek greater levels of collaboration within the federal government and without, and to focus our efforts on four grand challenges, two of which focus on the sciences: Unlocking the Mysteries of the Universe and Understanding and Sustaining a Biodiverse Planet.

Unlocking the Mysteries of the Universe

Since the late 1800s, the Smithsonian has played a lead role in understanding the fundamental nature of the universe, dark matter, and galaxy formation. The Smithsonian, particularly the Smithsonian Astrophysical Observatory (SAO), the National Air and Space Museum (NASM), and the National Museum of Natural History (NMNH), focuses on applying the integrative research of our scientists to today's big questions regarding the origin and evolution of the Earth, planets, stars, galaxies, and the universe. We have long-standing partnerships in our efforts with universities like Harvard, MIT, and Cal Tech as well as with the National Aeronautics and Space Administration (NASA) and other federal agencies.

Areas of focus include the study of the origin and evolution of the Earth and solar system, the effects of geologic and meteoric phenomena on Earth's atmosphere and biosphere, and discovery and characterization of exo-planets, particularly those that might sustain life systems. We are charged with maintaining the National Meteorite Collection which is used by our scientists and hundreds of others in understanding the composition of bodies from our solar system and beyond. We also are among the leaders in developing the next generation of ground- and space-based astronomical telescope mirrors and instrumentation that will enable the next generation of research. To cite one important example, our Solar Wind Electrons Alphas and Protons (SWEAP) program is a SAO-based investigation that will directly measure the properties of plasma in the solar atmosphere on the NASA mission "Solar Probe Plus," which will go into the Sun's atmosphere for the first time in 2018.

Understanding and Sustaining a Biodiverse Planet

Building from our strengths found at NMNH and in its world-class collections, the National Zoo and its Smithsonian Conservation Biology Institute (SCBI), the Smithsonian Tropical Research Institute (STRI), and the Smithsonian Environmental Research Center (SERC), we bring resources that allow us to understand biodiversity in a broad context. Our research investigates questions like: how to sustain a biologically diverse Earth in the face of growing populations; how does the earth's biodiversity change across geography and through time; and how do we understand the life-sustaining services of ecosystems and best sustain their contributions to human well-being locally

and globally?

While there are others who contribute research in developing answers to important questions, the Smithsonian is unique in providing access to the largest scientific collection in the world and being proficient in making long-term observations that help provide information needed to understand biodiversity in a changing world. The collections, developed over more than 150 years, have found a new life as new scientific tools like genomics have been introduced. Not only our scientists, but thousands of others have access to the collections.

Our ability to undertake large scale long-term observations is enhanced because our science is respected around the world, allowing us to form partnerships with scientists in universities, other agencies, and other nations. Our Forest Global Earth Observatory (ForestGEO) is a global network of forest research plots and scientists that have been dedicated to the study of tropical and temperate forest function and diversity for more than three decades. The multi-institutional network comprises 53 forest research plots in 23 countries across Africa, Asia, Europe, and the Americas, like the Lilly-Dickey Woods in Nashville, Indiana, in total monitoring the growth and survival of more than 4.5 million trees and more than 8,500 species. ForestGEO increases scientific understanding of forest ecosystems, guides sustainable forest management and natural-resource policy, monitors changes impacting forests across the globe, and builds capacity in forest science. The Smithsonian serves as the lead in the work, providing a host site for all of the data that are shared with partner institutions and nations.

In conjunction with the ForestGEO program, the Smithsonian has been funded by the National Science Foundation (NSF) to establish another long-term observation site located at the Zoo's Conservation Biology Institute in Front Royal, VA. NSF recently made a large investment in NEON, the National Ecological Observation Network, to create a continental observatory network aimed at understanding environmental patterns and processes in a coordinated and comparative long-term fashion.

Using the impetus of our strategic plan we have recently launched a marine version of the ForestGEO concept. Known as the Tennenbaum Marine Observatories Network (TMON), it will be the first worldwide network of coastal ecological field sites to comprehensively study marine biodiversity in a changing planet. TMON is unique among existing ocean observing efforts in several ways: it is a global network; it has standardized protocols; and it is focused on biodiversity and coastal regions—where people interact most intensively with the ocean. Each observatory will regularly sample local habitats for environmental drivers, habitat structure, biodiversity and community structure, and ecosystem processes. This information will give us a comprehensive, real time understanding of the complex relationships among the oceans and the life within and surrounding them.

Complementing the TMON initiative, Smithsonian scientists are among the leaders in the world in studying the dwindling population of coral reefs. These reefs are critical to sustaining life in the oceans as well as a significant economic driver for many tropical

economies. Our scientists have developed a conservation program for coral species, using cryopreservation to freeze sperm and embryos in a genetic bank to preserve them for future use to replenish this endangered species.

Our work in biodiversity also serves other practical ends, including understanding causes of the spread of zoonotic diseases, the source of 75% of diseases that afflict humans. We work with our armed forces and civilian air transport agencies to avoid damages to aircraft due to bird strikes, help agricultural experts develop defenses against invasive insects, monitor the movement of invasive marine species, and provide expertise regarding the impact of volcanic eruptions on human and animal populations.

Then there are times when our scientists provide us with a new look at our world. Using our collections and painstaking fieldwork, a team of our scientists from NMNH has discovered over 100 new species in the past fifteen years. Most recently, and announced to wide acclaim, the team identified the first new carnivorous mammal species discovered in the Americas in the last 35 years, the olinguito, a creature that lives in the cloud forests of the Andes. Their work illustrates the importance of continuing the endeavor to understand the true nature of the biodiversity of our world.

The Strategic Plan: Technology, Education and Access

In addition to our goal to discover new knowledge through research, we seek to share what we learn with as many people as possible.

Visitation to our museums and galleries is up by five million, exceeding 31 million last year, the highest attendance in a decade. This is not an accident, but the result of hard work by dedicated professionals to mount nearly 100 new educational exhibitions a year. If you cannot come to the nation's capital, we come to you through our loans of iconic national treasures to our network of affiliate museums, as well as our Smithsonian Institution Traveling Exhibition Service, which reaches nearly 5 million Americans every year in communities around the nation.

Digital technology has allowed the Smithsonian to reach new, diverse audiences and more people than ever before. We have more than 270 Smithsonian websites that last year attracted more than 140 million unique visitors, more than 3.8 million social media followers on Facebook and Twitter and many more on nearly 600 other social media sites, and more than 50 mobile apps that allow us to engage the public. We are committed to opening access to our collections. Today more than 8.5 million records and nearly one million images are available to the public through our main website's Collections Search.

Our digital badging program (similar to merit badges in scouting) is called Smithsonian Quests. More than 15 of our units are participating in this exciting new digital tool to motivate young learners and give them credentials for material they mastered. With the help of a MacArthur Foundation grant we now have nearly 3,000 registered users from all 50 states and more than 50 countries. For example, our recent conference series "Water Matters" looked at water from all of the Smithsonian's perspectives—science,

history, art, and culture—and the students' badging work reflected this interdisciplinary approach. A third-grader in Florida earned an "Oral Historian" badge by interviewing her longshoreman grandfather about his life on the Philadelphia docks. An eighth-grader in North Carolina earned an "Arts Advocate" badge for work that included writing a song about water conservation, "We Are Never Ever Wasting Water," and a classmate earned the "Invasion Investigator" badge through original species research and producing a podcast about the human role in species invasion. And, as one teacher noted, "I was teaching STEM courses and having a difficult time coming up with lessons that would be fun and interactive, but also rigorous and relevant. After using Smithsonian Quests for just two weeks, I noticed a substantial change in the way my students were learning. By putting them in charge of their education, they are able to choose assignments that best fit their skill set."

We, too, are expanding our skill set. Through our Digitization Office, we are becoming leaders in the field of 3D scanning, allowing our treasures and specimens to be seen in an entirely new light. We recently unveiled our new Smithsonian X 3D Explorer which currently features twenty items from the collection, including Lincoln's life masks, the Wright Flyer, fossil whales, and a remnant of the CasA supernova. Not only can each object be explored from every angle on the Internet, but they also can be printed out via 3D printer for scientific research or use in the classroom. I recently had the honor of becoming the first Secretary of the Smithsonian to be scanned and printed—it is a strange sensation to hold a tiny version of yourself in your hands. Soon, students everywhere will be able to do the same. This technology is another step in our efforts to bring the Smithsonian to the nearly 300 million Americans unable to come to us every year.

We now deliver educational materials to students and teachers in all 50 states. More than 2,000 learning resources, all tied to state standards and including K-12 science materials, are available online for free.

Smithsonian Science Education Center

For 28 years, the Smithsonian Science Education Center (SSEC) has been addressing science education, and we want to scale up our efforts to reach more students and teachers. The Smithsonian Science Education Center's LASER (Leadership and Assistance for Science Education) Program is an innovative STEM program, internationally recognized for its work to improve K-12 science education. The LASER model has been implemented successfully in school districts including Alabama, southern California, Delaware, regions of New Jersey, Pennsylvania, northern New Mexico, Rhode Island, and Washington State since 1985. To date, 3 million students in classrooms around the country and online have taken part.

SSEC won a highly competitive i3 grant from the U.S. Department of Education, now serving thousands of children in underserved areas. In addition to the $26 million in federal grant funding, SSEC was able to raise $7.5 million for this effort in matching funds from the private sector. The study involves approximately 90,000 students in elementary and middle schools from districts in three locations—New Mexico, Houston,

from Texas and North Carolina. Approximately 70% of the students in the i3 regions are characterized as under-resourced. SSEC is currently beginning the fourth year of the i3 grant.

Last month, the Smithsonian Science Education Center launched its new workforce development initiative, developing programs in partnership with key stakeholders, such as community leaders, corporations, universities, private foundations, and community colleges to create and sustain a viable workforce. These programs will be delivered through formal and informal means that are designed to enhance the skills of people to gain and maintain good jobs by eliminating the barriers to employment. We will focus on:

- Sustainable Education Platforms
- Increased investment from public and private sectors
- Serving Community Needs
- Assessment

We have a pilot program in New Orleans and another in the works for Chattanooga, Tennessee.

Our expertise and experience as a research institution and as an educational institution, coupled with our global reach and ability to convene stakeholders, uniquely position us to take this workforce development initiative to scale.

Our partnership with the ePals global community enables us to offer our lesson plans and resources to more than one million schools. The Smithsonian Learning Center within ePals has had more than 3.3 million visitors and 8.2 million page views, including more than 410,000 downloads of classroom work based on Smithsonian content.

Federal Government and University Partnerships

To avoid duplication of effort and facilities and bring teams together, we have developed and strengthened partnerships with many federal entities, including NASA, the National Oceanic and Atmospheric Administration (NOAA), the National Institutes of Health (NIH), the U.S. Patent and Trademark Office (PTO), the Department of Education, the Department of Defense (DoD), the Department of Education, the Department of Interior (DoI), the Department of Agriculture (USDA), the State Department, the National Park Service (NPS), the National Archives, the Library of Congress, and the Office of Science and Technology Policy (OSTP). In August, we signed an MOU with the U.S. Agency for International Development (USAID) that will better enable us to work together on conservation research, wildlife management, and cultural preservation in support of the objectives of USAID and our nation. Working together, we can solve issues in ways that would not otherwise be the case.

The Smithsonian is an active partner in the broader efforts to coordinate STEM efforts across the federal government. We have worked closely with agencies such as NASA,

NIH, NOAA and the U.S. Forest Service to improve programming at our own museums, better inform their outreach, and on joint initiatives such as Waterways, a project that increases individual awareness about the environment and eco-stewardship.

We have also built collaborations with more than 60 universities across the country on a wide variety of issues: Harvard, Yale, MIT, Columbia, Carnegie-Mellon, Tulane, UCLA, Michigan, UNC, Virginia Tech, LSU, and many others. We have put significant effort into science with many of these, including our seed grant programs with the University of Maryland at College Park and The George Washington University. With George Mason University we created the Smithsonian-Mason School of Conservation at the National Zoo's Smithsonian Conservation Biology Institute in Front Royal, Virginia. This groundbreaking program is one of the premier destinations in the world for students who aspire to understand the complexities of biodiversity and become leaders in the burgeoning field of conservation biology.

Award-winning Scientists Tackling Practical Problems

More than 500 Smithsonian staff scientists, augmented by an equal number of fellows and hundreds of international collaborators, conduct research in field stations and laboratories on all seven continents, and serve as national and international experts in a wide range of disciplines. Our award-winning scientists include 19 members of the National Academy of Sciences, 47 American Association for the Advancement of Science Fellows, and, in the three years we have participated in the program, three Presidential Early Career Awards for Scientists and Engineers (PECASE) awardees. This is the highest honor the United States government bestows on science and engineering professionals in the early stages of their independent research careers. In the past 10 years, our scientists have published more than 500 articles in the major science journals including 120 in *Nature*, 178 in the *Proceedings of the National Academy of Sciences* (PNAS—including two cover stories in 2013), and 214 in *Science* (including two cover stories in 2013).

More than 1,300 students interned with us last year, working with our scholars and learning by visiting our field stations, museums, galleries, libraries, and the National Zoo. They come to take part in our exciting scientific discovery; we welcome the opportunity to help them grow to be the nation's next generation of scientists.

Smithsonian scientists are based in a group of key facilities and units, many with long and distinguished histories.

Museums

The Smithsonian is home to the National Museum of Natural History (NMNH), the National Air and Space Museum (NASM) on the National Mall and the Steven F. Udvar-Hazy Center at Dulles International Airport, the National Zoological Park in Washington, D.C., and the Zoo's Smithsonian Conservation Biology Institute (SCBI) in Front Royal, Virginia.

NMNH is not only the most visited science museum in the world; it is also home to first-class science in botany, biology, zoology, paleontology, anthropology, archaeology, ornithology, earth sciences, and volcanology. Its collections, with more than 127 million specimens and objects, are the largest on the globe. Digital access is increasingly bringing these assets to scholars and citizens worldwide.

NMNH also houses the Consortium for the Barcode of Life (CBOL), an international initiative devoted to developing DNA barcoding as a global standard for the identification of biological species. The new technique uses a short DNA sequence from a standardized position in the genome as a molecular diagnostic for species identification. As the recognized U.S. leader in DNA barcoding, the Smithsonian seeks to increase its research and training capacity. These activities directly support the biodiversity theme of our Strategic Plan, and also link to access initiatives such as ForestGEO and the Encyclopedia of Life.

The Encyclopedia of Life (EOL), another global partnership based at NMNH, is an ambitious project that will become the world's most comprehensive repository of information about every form of life on Earth. It is expected to encompass the 1.9 million known species of animals, plants, and other life forms in about 10 years. The EOL website is designed to provide free, open access to scientists, educators and students alike. Last year 4.6 million people visited EOL.org from every corner of the globe, making it one of the most popular Smithsonian websites.

In an effort to excite young people about science, last month NMNH opened Q?rius, a new, interactive education center aimed at our teenage visitors. By offering them the opportunity to engage with our scientists, examine specimens, and learn about the world around them, Q?rius will help inspire young people to seriously consider careers in science.

Combined, our science museums and the National Zoo host more than 18 million visitors annually, offering the largest single opportunity in the world to educate the public about science. The scientific research done by the Smithsonian informs exhibits at museums and the Zoo. It provides advanced, up-to-the-minute data that drive our extensive educational outreach to schools across the country.

Smithsonian Centers of Research

The nature and scope of Smithsonian science is global, involving activities on every continent. In addition to the museums, Smithsonian science is driven by a group of leading research centers. They take on collaborative projects that cross disciplines and build on physical platforms not found in the museums.

Smithsonian Environmental Research Center (SERC), Edgewater, MD

SERC is the leading national research center for understanding environmental issues in

the coastal zone. Its scientists engage in interdisciplinary studies that address issues such as global change, watershed pollution, the maintenance of productive fisheries, the changes wrought by invasive species, and the ecology of fragile wetlands and woodlands. Thanks to the support of the Congress, scientists at SERC this year will fully occupy the expanded and remodeled Mathias Laboratory, named after former U.S. Senator from Maryland, Charles "Mac" Mathias. This new 69,000 square foot lab built to meet LEED Platinum standards reduces its environmental impact on all fronts—from where it gets its power to where it gets its materials. It is estimated that the Mathias Laboratory will consume at least 37 percent less energy and emit 37 percent less carbon dioxide than a similar building that meets baseline LEED certification standards. The reach of SERC science on land and water ecosystems extends beyond its home on the Chesapeake Bay to the Atlantic, Gulf of Mexico, and Pacific coasts, and the Mathias Laboratory will strengthen those efforts.

Smithsonian Tropical Research Institute (STRI), Panama

STRI is the world's premier tropical biology research institute. What began in 1910 as an effort by the Smithsonian to survey flora and fauna before the completion of the Panama Canal, STRI has grown to become a world leader in preserving tropical forests and the ecosystems found there. Dedicated to increasing our understanding of the past, present, and future of tropical biodiversity, and its relevance to human welfare through studies in marine biology, terrestrial ecology, and paleontology, STRI's facilities provide a unique opportunity for long-term ecological studies in the tropics. The facilities are used extensively by both Smithsonian scientists and hundreds of visiting scientists from around the world. In 2014, STRI's 35,000-square-foot, green-certified research complex in Gamboa will open, enhancing the ability of scientists there to study and preserve tropical ecosystems.

Smithsonian Astrophysical Observatory (SAO), Cambridge, MA

SAO is one of the largest and most diverse astrophysical institutions in the world; scientists there carry out a broad program of research in astronomy, astrophysics, earth and space sciences, and science education. The Observatory's mission is to advance our knowledge and understanding of the universe through research and education. Boasting some of the world's finest scientists, SAO operates large land- and space-based telescopes that reveal the universe and also builds the remarkable instruments needed to make it possible. SAO operates Chandra, NASA's flagship mission for X-Ray astronomy, and has been selected by the space agency to build the Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument, the first space-based instrument to monitor major air pollutants across North America. In June, several SAO researchers took their place among the most creative and respected thinkers in the country at the Aspen Ideas Festival in Colorado.

National Zoological Park (NZP)/Smithsonian Conservation Biology Institute (SCBI), Washington, D.C. and Front Royal, VA

National Zoo scientists are based at the Zoo in Washington, D.C., the Smithsonian Conservation Biology Institute in Front Royal, VA, and at field sites around the world. They conduct research to aid in the survival and recovery of species and their habitats, and ensure the health and well-being of animals in captivity and in the wild. During the past 31 years, nearly 6,000 people from 116 countries have been trained through the Zoo's professional programs in conservation biology and zoological medicine. In addition, the Zoo cares for more than 2,000 animals representing 400 different species.

In 2013, the Zoo received its five-year accreditation from the Association of Zoos and Aquariums which certified that the National Zoo has met or exceeded the AZA's standards for animal care, veterinary programs, conservation, education, and safety. The Zoo also celebrated the birth of the Giant Panda cub Bao Bao, two Sumatran Tiger cubs, and fifteen cheetah cubs—all significant births as their species are considered critically endangered, endangered, or vulnerable.

In December, the Zoo launched "Partners in the Sky," a partnership with the aerospace industry to use the latest satellite technology to track any animal, anywhere in the world, at any time. At the event, they issued the "One-Gram Challenge" to develop an ultra-lightweight tracking device that could be affixed to the smallest of birds.

National Air and Space Museum (NASM), Washington, D.C.

Scientists at NASM's Center for Earth and Planetary Studies, a NASA-supported program, study a variety of geological processes, such as volcanism, floods, crater formation, tectonics, and sand movement. Many of the studies also address topics of concern for understanding changes to the planet's climate. The scope of research activities includes work on Mercury, Venus, the Moon, Mars, asteroids, and satellites of the outer solar system.

A NASM geologist was selected by NASA in November 2012 to be a Participating Scientist on the Mars Science Laboratory Curiosity mission. Our "Long Term Planner" works to establish the strategic goals and plans for the science team and rover, and uses data from Curiosity to understand the processes responsible for shaping the landing site in Gale crater.

Museum Conservation Institute (MCI), Suitland, MD

Researchers use state-of-the-art instrumentation and scientific techniques to provide technical research studies and interpretation of art, as well as anthropological and historical objects. Their work assists scientists, art historians, and conservators as they place objects within a culture and a time period, look for new cultural influences within societies, and compare cultural and technological change across different periods and geographic areas.

National Collections

Scientific collections are an essential component of the national scientific infrastructure, as documented in the 2009 report of the Interagency Working Group on Scientific Collections (OSTP, 2009). Irreplaceable and comprehensive, the Smithsonian has the richest, largest, and most-used natural history collection on Earth. Tens of millions of artifacts and specimens, some as old as the Earth itself, serve as a baseline against which to measure change; they are a reference for Smithsonian scientists and those in other federal agencies as well as scientists around the world who study processes that have modified Earth and shaped the human environment. They reflect a legacy of more than 150 years of research, exploration, discovery, and conservation, and they inform Smithsonian publication, education, and exhibition. Universities have researchers, but not extensive collections. Our collections set us apart from all other research and scholarly institutions.

New technologies in genomics and biochemistry allow new layers of information to be extracted from old museum specimens, but they also raise new challenges regarding storage that we are addressing through our cryo-preservation initiative.

Our collections are used by novices and experts alike. For example, NMNH collections are used to support invasive species identification, and National Zoo collections are used to support research on wildlife health and epizootic disease. The Natural History building on the National Mall permanently hosts personnel from four federal agencies, including USDA, who identify and research invasive species. The next invasive pest can be anything from anywhere in the world, so a comprehensive global collection and library are vital to rapid identification, thus empowering informed and effective management. USDA shares the costs of development and curation of the NMNH insect collection, and both staffs use the robust collection to identify more than 15,000 lots of insects annually in support of border protection and agriculture research.

To cite one example, the Emerald Ash Borer, a green beetle, is one of the most damaging invasive species in the United States (and Canada). It is responsible for killing tens of millions of trees and its economic impact has been significant. Based at NMNH and using our collections, a USDA biocontrol program is working on the taxonomy of parasitic wasps that might serve as biocontrol agents. The Emerald Ash Borer (EAB) Program works to prevent the spread of EAB and mitigate the damage it causes to America's ash trees. The native range of the Emerald Ash Borer includes China, Mongolia, North Korea, South Korea, Japan, Taiwan, and the Russian Far East. The EAB was unknown in North America until its discovery in southeast Michigan in 2002. Today, EAB infestations have been detected in 20 states; Connecticut, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin.

Four federal agencies (U.S. Geological Survey, DoD, USDA, and DoI) spend roughly $6 million annually to base 100 people in our natural history collections to fulfill their agency missions. In addition, the FAA and DoD work closely with NMNH to carry out bird-strike identifications using collections-based studies.

It is important to again underscore that our collections are national collections, in fact *the* national collections. They are made available to answer questions raised by scientists and researchers from across the country and around the world. We measure those individuals unaffiliated with the Smithsonian who come to visit our non-exhibited collections for the purpose of research or education in terms of visitor days. Last year, we had over 45,000 visitor days. In fiscal year 2012, we loaned more than 2.2 million objects and specimens to qualified recipient institutions and individuals.

The Future

With the help of our 6,500 employees, more than 6,200 volunteers, and extensive collections, and through internal and external collaborations, the Smithsonian is focused on addressing important issues in science today, working to improve scientific literacy, and aiming to ensure a brighter future for us all.

To maintain its cutting-edge research, educational outreach, and groundbreaking discoveries in the years to come, the Smithsonian relies on both public and private support and is grateful for both.

You may have heard of high school sophomore Jack Andraka, who devised an inexpensive and quick test for pancreatic cancer. For that, in 2012 the Smithsonian presented him the Smithsonian American Ingenuity Award for youth achievement. As a young boy, Jack was inspired by going to the National Museum of Natural History with his parents. On awards night, he inspired all of us when he said, "Instead of taking pictures of your food tonight and posting them on Instagram, how about instead—change the world with your ideas."

That is the true power of science—to change the world with ideas and make it a better place. At the Smithsonian, that is what we strive for every day.

Thank you for this opportunity to share with you some of the unique aspects of the Smithsonian Institution's science efforts.

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Wayne Clough
Secretary of the Smithsonian Institution

Wayne Clough is the Secretary of the Smithsonian Institution, the world's largest museum and research complex with activities in nearly 100 countries. The Smithsonian includes 19 museums and galleries, 20 libraries, the National Zoo and numerous research centers, including the Smithsonian Astrophysics Observatory, Smithsonian Tropical Research Institute and the Smithsonian Environmental Research Center.

Since becoming Secretary in July 2008, Clough (pronounced "cluff") has taken the Smithsonian in new directions. A comprehensive strategic plan—the first of its kind for the Smithsonian—created a new framework for goals, enterprises and operations. The Smithsonian is working in new and cross-disciplinary ways—focused on four grand challenges: Unlocking the Mysteries of the Universe, Understanding and Sustaining a Biodiverse Planet, Valuing World Cultures and Understanding the American Experience.

Building on the Smithsonian's core strengths, the strategic plan has renewed its commitment to education, understanding the causes and effects of global change and expanding access to the Smithsonian's vast expertise and collections. In the process, the Smithsonian is becoming a leader in the use of new digital communications and imaging technology.

Clough is responsible for an annual budget of $1 billion, 6,400 employees and 6,200 volunteers. The Smithsonian receives about 65 percent of its funding from the federal government while generating additional funding from private contributions and business revenues. Since Clough's arrival, the Smithsonian has raised more than $766.5 million in philanthropic gifts through January 2013.

The Smithsonian reaches Americans in all 50 states through such programs as the Smithsonian Institution Traveling Exhibition Service, Smithsonian Channel, Smithsonian magazine and hundreds of programs available through the Internet. Clough supported the Smithsonian's first-ever branding and ad campaign with a website, seriouslyamazing.com, reaching target audiences (ages 18-34) primarily through social media and allowing them opportunities to interact with Smithsonian experts.

Clough is overseeing a building and renovation program of more than $1 billion. Major elements include the renovation of the Arts and Industries Building on the National Mall, scheduled to reopen in 2014, and the construction of the National Museum of African American History and Culture located near the Washington Monument, scheduled to open in late 2015.

Since coming to the Smithsonian, the Secretary has emphasized the development of collaborations with universities and other organizations. Examples include the Global Tiger Initiative with the World Bank, accessioning of the Space Shuttle Discovery with NASA and the Haiti Cultural Recovery Project with the State Department. In 2012, the Smithsonian opened the Smithsonian-Mason School of Conservation in Front Royal, Va., in partnership with George Mason University. As part of a degree program, students conduct research on endangered species with Smithsonian scientists.

Since Clough became Secretary, more than 400 exhibitions have opened across the Smithsonian. He has overseen the opening of major permanent exhibitions, including the Hall of Human Origins at the National Museum of Natural History, the new elephant habitat and trail at the National Zoo and the new wing at the National Air and Space Museum's Steven F. Udvar-Hazy Center.

The Secretary has been the subject of a number of profiles and articles in national media and a guest on several TV programs. In 2011, Clough was featured in an answer in the category "People Who Matter" on the television quiz show, Jeopardy. And last year, he was featured in the "Not My Job" segment of National Public Radio's news quiz program Wait Wait...Don't Tell Me!

Before his appointment to the Smithsonian, Clough was president of the Georgia Institute of Technology for 14 years. He received his bachelor's and master's degrees in civil engineering from Georgia Tech in 1964 and 1965 and a doctorate in 1969 in civil engineering from the University of California, Berkeley. He has received nine honorary doctorates from universities in the U.S. and abroad.

Clough was a member of the faculty at Duke University, Stanford University and Virginia Tech. He served as head of the department of civil engineering and dean of the College of Engineering at Virginia Tech and as provost at the University of Washington.

During his tenure at Georgia Tech, the school was ranked among the top 10 public universities by U.S. News and World Report. In 2012, Georgia Tech opened the G. Wayne Clough Undergraduate Learning Commons Building to honor his commitment to undergraduate students.

Clough's recognitions include 2012 National Honor Member status in Chi Epsilon, the National Civil Engineering Honor Society, the 2011 Foreign Policy Association Medal, the American-Russian Cultural Cooperation Foundation Award in 2011, membership in the American Academy of Arts and Sciences in 2010 (he currently serves on its Commission on the Future of Humanities and Social Sciences), induction into the Technology Hall of Fame of Georgia (2009) and the Joseph M. Pettit Alumni Distinguished Service Award (2009) that recognizes a lifetime of leadership, achievement and service to Georgia Tech.

Elected to the National Academy of Engineering in 1990, he was recognized with the 2008 NAE Bueche Award for his efforts in public policy. Clough has received nine national awards from the American Society of Civil Engineers, including the 2004 OPAL lifetime award for contributions to education and the 2010 Presidents' Award. He has served as chair of the National Research Council Committee on New Orleans Regional Hurricane Protection Reconstruction, a six-year term as member of the National Science Board and seven years as a member of President's Council of Advisors on Science and Technology.

Clough's interests include science, museums, technology and higher-education policy, sustainability, international programs and history. His civil engineering specialty is in geotechnical and earthquake engineering. He has published more than 130 papers and reports. His most recent publication is "Increasing Scientific Literacy: A Shared Responsibility" (2011), a monograph on the nation's urgent need to improve the scientific literacy of its citizens and the key role the Smithsonian can play toward that goal.

Chairman BUCSHON. Thank you very much.

I have subscribed to Smithsonian Magazine, by the way, for many, many years. I would recommend it to everyone. It is a great magazine.

Dr. CLOUGH. Thank you.

Chairman BUCSHON. Now, I recognize Under Secretary Pell for five minutes for her testimony.

TESTIMONY OF DR. EVA PELL,
UNDER SECRETARY FOR SCIENCE,
SMITHSONIAN INSTITUTION

Dr. PELL. Thank you for the opportunity to testify.

To most people, the Smithsonian conjures a public place on the National Mall. We are a remarkable tourist destination, but behind that is a world-class research infrastructure making a difference in the lives of Americans.

The Smithsonian conducts scientific research through a blend of remarkable collections, field sites and observatories on Earth and in space. These assets allow our scientists and collaborators to address significant questions from understanding the origin of the universe to explaining losses in biological diversity around the globe.

To demonstrate the rich depth and breadth of Smithsonian science through collections research, exploration, and educational outreach, I would like to take you on a journey, a journey of flight. We are cleared for takeoff from the Hill, so let's take a short hop down the Mall. We land at our National Air and Space Museum where our future pilots, engineers, and astronauts look at the museum's impressive collections encompassing 60,000 objects ranging in size from rockets to space helmets to microchips. These youngsters attend lectures, family events, and educational programs that often feature pioneers in aviation and space, including pilots, astronauts, and scientists. Each day, explainers bring the science of flight alive in the How Things Fly Gallery.

We continue our journey now and explore the real dangers that airplanes face. You met our scientist Dr. Carla Dove, who is instrumental in keeping you and millions of pilots and passengers safe in flight on both commercial and military flights. Dr. Dove is an ornithologist and a forensic expert who identifies the birds that can cause airplane crashes like that of the commercial flight in the Hudson River in January 2009.

Carla runs the Smithsonian's feather identification lab at the National Museum of Natural History. The aviation industry relies on Carla and her lab to identify the birds involved in thousands of collisions with planes every year. The Smithsonian has interagency agreements with the Federal Aviation Administration, the U.S. Air Force, and the Navy. Carla's identifications help scientists and engineers take action to avoid a crash through activities like altering an airplane's flight path or implementing bird habitat management schemes at airports. Carla receives more than 8,000 samples per year, called "snarge," to identify birds via feather identification or DNA analysis. We can help because of our unique comprehensive collection and the specialized training of our staff. Thanks to Carla, we are safe to continue our metaphorical flight.

Now, we are going to go and visit some continents: Asia, Africa, and South America. The question is, when we go home, how do we know we are going to be alone? What if a virus, a rodent, or an insect is hitchhiking a ride on our plane? We or others we come into contact with may end up getting sick when we get home.

The diseases can be caused by pathogens that are carried by animals and insects causing zoonotic diseases that are spread between animals and humans. You have heard of SARS, malaria, and West Nile virus infection. In fact, about 75 percent of recently emerging infectious diseases affecting humans originally infected animals. Because of extensive international air travel, these diseases can travel undetected very quickly, posing serious public health and economic threats.

To respond to these diseases, the Smithsonian is a partner with USAID on the PREDICT project, charged with predicting and preventing such problems. Our scientists help build pathology skills so that scientists in the developing world can help identify the cause of animal deaths, both wildlife and agricultural, often an important indicator of disease threats that could jump to humans.

In November of last year, scientists in the Middle East found a disease caused Middle East Respiratory Syndrome in camels in Qatar. The SARS-like coronavirus, which emerged last year, has killed 40 percent of the 170 people to whom this virus was transmitted from camels. Pinpointing camels as the disease required a range of tests, including DNA sampling and antibody testing. The Smithsonian was able to help by providing a baseline comparison for these samples through use of our collections, which include 30 years of banked serum from more than 100 species that we have at the National Zoo. The Qatari Health Counsel, armed with this information, was able to issue warnings for vulnerable populations to avoid close animal contact. Our scientists and colleagues have nipped this problem in the bud before it walked onto a plane.

Our brief journey has come to an end. We can land safely now. But the possibilities for future exploration for you and your constituents are endless at the Smithsonian. Please come visit our collections, our field sites, and our observatories. Meet more of our dedicated scientists, and I can promise you an incredible journey you will not forget. Thank you.

[The prepared statement of Dr. Pell follows:]

Smithsonian Institution

U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Research and Technology
Testimony of Dr. Eva J. Pell
Under Secretary for Science, Smithsonian Institution
14 January 2014

Thank you for the opportunity to testify and share information on the scientific research of the Smithsonian. As you know, the statutory mission of the Smithsonian is "the increase and diffusion of knowledge." Our research activities are the fulfillment of the first part of this mandate. From observations of the early universe to recent discovery of the olinguito, the Smithsonian is engaged in fundamental research about the constituent parts of our planet and universe and how they fit together. The research has developed new exciting cross-disciplinary and collaborative approaches to discovery in order to respond to the great challenges of our time. We are thankful to the Congress for its support.

The Smithsonian helps shape the future by preserving our heritage, discovering new knowledge, and sharing resources with the world. Our expertise is expansive as we work in disciplines that focus on sciences, biological and physical, that explain all facets of natural history; and in scientific and engineering disciplines needed for a comprehensive astrophysics program. We then use this research for the other half of our mandate—to inspire and educate children and families through engaging exhibitions both in our museums and online. We train and develop scholars at every level of their study, whether they visit the Smithsonian for a one-day field trip, a semester internship or extended post-doctorate research. And through premiere educational resources and lesson plans set to state standards in use by teachers across the country, we enhance the scientific literacy in America and beyond.

While some research institutions work in fields similar to those of the Smithsonian, we fulfill our mission in a way that is complementary to federal agencies and universities with which we partner. The federal appropriation we receive has allowed us to approach research from a long-term perspective. We can establish observatories that allow data collection for many decades; and from those studies come continually growing collections for use by scientists and citizens nationally and throughout the world.

Our scientific research complements but does not duplicate that of our partner federal agencies like U.S. Departments of Agriculture, Interior, Commerce, and Defense, all of which have staff in residence at our facilities; or our contracted partners such as the United States Navy, United States Air Force, Federal Aviation Administration (FAA), Environmental Protection Agency (EPA), and the Bureau of Ocean Energy Management (BOEM), for whom we develop the national collections

and shared expertise to enhance the quality and impact of federally-funded science for natural resource management. Our exceptional scientific staff collaborates regularly with research universities in the U.S. and beyond as faculty benefit from participation in our long-term research studies and we enjoy the complementary expertise these scientists bring to our programs.

Whether we are looking closely at the Earth to detail the impact of an invasive species on an ecosystem, or if we are looking back on the Earth to measure atmospheric pollution from space, the Smithsonian is steadily evolving, learning and sharing. We provide an interface that connects students and scholars, citizens and scientists, decision makers and the public, in dialogue about questions and challenges of yesterday, today, and tomorrow.

When the Smithsonian undertook the articulation of a new Strategic Plan in 2009 we framed our work around four broad "Grand Challenges" that reflect and focus the scholarly work of the Institution: *Understanding the American Experience, Valuing World Cultures*, and the science-focused challenges: *Understanding and Sustaining a Biodiverse Planet* and *Unlocking the Mysteries of the Universe.*

We have seven units that fall under the aegis of science at the Smithsonian: the National Air and Space Museum (NASM); the National Museum of Natural History (NMNH); National Zoological Park (NZP) which has two campuses, one at Rock Creek Park and the other the Smithsonian Conservation Biology Institute (SCBI) at Front Royal, VA; the Museum Conservation Institute (MCI) in Suitland, MD; the Smithsonian Environmental Research Center (SERC) in Edgewater, MD; the Smithsonian Astrophysical Observatory (SAO) in Cambridge, MA; and the Smithsonian Tropical Research Institute (STRI) in Panama.

To most people, the Smithsonian conjures a public place on the National Mall. We are a tourist destination but behind that is a world-class research infrastructure making a difference in the lives of everyday Americans. The Smithsonian is the curator of extensive scientific collections acquired and maintained primarily for the purpose of long-term research, enabling experts in each generation to address such significant challenges facing society such as the effects of environmental change, the spread of invasive species, and the loss of biological diversity and its impact on the global ecosystem. Last year we had more than 45,000 research visitor days to our collection holdings.

The Washington D.C.-based museums and the National Zoo are complemented by our expansive field sites and ecologically oriented research units viz. STRI, SERC and SCBI. Annually, more than 900 visiting scientists from academic and research institutions in the United States and around the world visit our Tropical Research Institute (STRI) facilities in Panama. Although STRI is based in Panama, research is conducted throughout the tropics and these sites provide a unique opportunity for long-term ecological studies. The continuity of their long-term programs enables in-depth investigations that attract an elite group of fellows and visitors.

The Smithsonian Astrophysical Observatory (SAO) has developed and operates world-class astronomical facilities in Massachusetts, Hawaii and Arizona. SAO's telescopes and instruments utilize forefront technologies operating across the electromagnetic spectrum, and enable one of the most productive astronomy programs in the world. SAO trains the brightest young astronomers who then take their experience and expertise with them into astronomy programs around the nation. In the past decade SAO fellows have taken up faculty positions at top flight, private and public universities in fifteen states.

Closer to home, the Environmental Research Center (SERC) sits on the western shore of Chesapeake Bay. It spans 16 miles of shoreline and 2,650 acres of forest. Scholars work alongside students and volunteers to run the world's longest running field experiment on atmospheric increases in carbon dioxide affecting plant communities, and the world's longest data record on the increase of ultraviolet solar radiation. SERC research forms an important base for understanding links between the natural and agricultural communities and with STRI enable the Smithsonian to pull together important knowledge of how systems work on a landscape level.

The digital information we have created from the Smithsonian collections, long term research sites, and astrophysical observations form national assets which both plumb fundamental questions of physics, biology, and environmental science, while providing the basis for education, learning, and wonderment.

The strategic plan has enabled us to leverage this fundamental work and information from the collections, research sites, and scholars into larger programs to understand life on this planet, the planet itself, and the universe within which it sits.

UNDERSTANDING AND SUSTAINING A BIODIVERSE PLANET

One of the Smithsonian's scientifically driven Grand Challenges is Understanding and Sustaining a Biodiverse Planet. Four units (NMNH, SERC, STRI and NZP) use the diversity of natural history and living collections, as well as strong ecological research and field facilities to tackle this grand challenge from a myriad of perspectives and from unprecedented long-term research data sets. The Smithsonian collaborates with U.S. Federal and state agencies, universities, research centers, and museums across the globe to tackle projects too complex for any one institution to undertake alone.

Our research helps to unlock the secrets of the past, but Smithsonian science is also keenly focused on the global challenges of the present and future. The Smithsonian is exceptional in its ability to undertake long-term studies that require large-scale data gathering. Research carried out over years and even decades is now recognized as fundamental and vital, both to scientific understanding and to society's ability to make informed policy choices about such issues as species conservation or coastline protection. According to National Oceanic and Atmospheric Administration (NOAA),

the shoreline accounts for less than 10 percent of the land available in the U.S. (excluding Alaska) yet at least 39 percent of the U.S. population lives in counties directly on the coastline.. Coastal areas are substantially more crowded than the U.S. as a whole, and population density in coastal areas will continue to increase in the future. Hurricane Sandy and other natural disasters have demonstrated, such populations are vulnerable to extreme weather incidents.

Global Earth Observation

In 1980, the first large-scale tree plot was established in Panama in an effort to understand why tropical forests were so diverse. Each tree with a trunk diameter greater than 1 centimeter was identified and measured within a 50-hectare area. All 230,000 trees in the plot have since been remeasured every 5 years. This plot seeded the idea for a global forest observatory system. ForestGEO (formerly called SIGEO) has become the foremost forest ecosystem observatory system in the world with 53 plots in 23 countries and over 80 partner institutions. This program is answering major questions on species diversity and survival, and the role of forests in global water and carbon cycles. Just last year, researchers from ForestGEO network produced 137 publications. From this work we have learned that the impacts of changing climate are complex. For example, in some temperate forests carbon is being taken up at an increasing rate; yet in tropical forests the reverse is true as trees are growing more slowly.

The program not only offers answers to basic science questions, but it also serves as an important platform to build capacity throughout the world through training and education. Federally appropriated funds toward SIGEO have leveraged significant private philanthropic support and competitive grant funding—more than $39 million to date.

NEON

NEON, the National Ecological Observation Network, is a large recent investment by NSF to create a continental observatory network aimed at understanding environmental patterns and processes in a coordinated and comparative long-term fashion. For 30 years starting in 2017, a series of 60 towers, laboratories in the sky, will continuously measure many variables in 20 different types of ecosystems in a precise and comparable fashion. The Smithsonian is honored to have its facilities in Front Royal chosen as the hub of the Mid-Atlantic foundational site, with a satellite site planned for the Chesapeake environs at our SERC facility. This will build on the ForestGEO program and enable new depth of analysis of important environmental patterns. At each NEON site researchers will monitor atmospheric, chemical, and soil conditions while collecting biodiversity samples of insects, birds, plants, small animals and microbes to better understand the diversity of the United States. Annually, airplanes carrying laser equipment will fly over the forests to create high-resolution digital scans of the tree canopy so scientists can track its density and growth. The NEON project will also incorporate data from 46 aquatic sites to paint a

more complete picture of our ecosystem nationwide. This partnership of unprecedented comprehensive scale leverages federal investment in the facility and builds on our history and success in long-term research sites.

Marine Global Earth Observatory Network

In parallel to terrestrial monitoring, the Smithsonian recently received a $10M gift for an endowment from a private donor to launch the Tennenbaum Marine Observatory Network. It is designed to measure biodiversity in coastal marine environments and to measure the physical parameters important to this critical habitat for all manner of organism. The Smithsonian is initiating sites on the Chesapeake at SERC, at the Ft. Pierce Marine Station, part of NMNH, in Belize where the Smithsonian has 30 years of active marine research and in Panama both on the Caribbean and Pacific coasts. Environmental parameters to be measured will include temperature, salinity, pH, and dissolved oxygen; biodiversity will be measured through sampling of plankton, sea grasses, invertebrates etc. Specimens will be deposited in the Smithsonian collection. In addition, the sites will monitor plant productivity, grazing and other measures of biological activity. We anticipate quick expansion of the program to include partnerships on the West Coast of the U.S. and throughout the rest of the world, just as in the successful ForestGEO program discussed above. This work was planned over the last few years in consortium with colleagues at NOAA, EPA, and universities and fills a gap in coastal observations that has long been recognized.

Genomics as a tool to understand biodiversity

The Smithsonian has recently expanded our genomic collections and research capabilities, including a new laboratory housed at the Natural History Museum. There are many uses for genomic information including a much deeper understanding of the taxonomy and systematics of the species on our planet. But there are also very practical applications of this type of knowledge. For example, there are specific gene sequences that are unique to individual species. These small sections of DNA can work just like a bar code in the grocery store to identify species with great precision. Researchers are using barcoding to discover new species, refine our understanding of species we've already found, and provide ecologists, other scientists and society with a cost-effective way to identify species.

The Consortium for the Barcode of Life (CBOL) is an international initiative devoted to developing DNA barcoding as a global standard for the identification of biological species. CBOL has 200 member organizations from 50 countries and operates from a secretariat office located in the Smithsonian's National Museum of Natural History in Washington, DC. The Fifth International Barcode of Life Conference was held in October 2013 in China, and demonstrated how rapidly this international initiative has grown.

CBOL catalyzes international partnerships and the use of barcode data for the benefit of science and society. The impacts of this research may contribute a critical tool to protecting endangered species. More than 35,000 of the world's 1.8 million named species are in danger of regional or global extinction. Intercepting wildlife as they are transferred across borders is critical to slowing illegal trade, but current detection tools are inefficient, expensive and unreliable.

Google through their Global Impact Awards has recognized the promise of DNA barcoding in protecting wildlife. In 2013, CBOL received a $3 million grant to help create a 'DNA barcoding' library so law enforcement officials can easily identify illegal trade species and better protect the world's most endangered wildlife.

This two-year project devoted to protecting endangered species will involve six country partners, including South Africa, Kenya, Nigeria, and Mexico, and will help to train enforcement officials to disrupt illegal animal trade.

Wildlife Conservation

The Smithsonian is engaged in conservation at many levels, from fundamental research to understand loss in species biodiversity, to public outreach and education, to domestic and international training. As an example, the National Zoo has embarked on a major amphibian conservation effort. Since 1980, 122 amphibian species are thought to have gone extinct with huge implications for insect control, compared to the loss of just five bird species and no mammals over the same period. This is an unprecedented rate of species loss and deserves an unprecedented conservation response.

In Panama, our collaborative research has identified the microscopic chytrid fungus is to blame in the unprecedented decline of amphibians worldwide. The fungus works by infecting the skin of the animal and starving it of oxygen. To mitigate this threat, researchers are hard at work to capture and breed the endangered frogs. The hope is to learn to raise these animals in captivity until enough is known about the disease to allow researchers to release amphibians into the wild once again.

In November, staff moved into our new Amphibian Rescue Center (ARC) in Gamboa. Panama. Our partnerships with zoos, aquariums, grantors and private industry are evident at this new center. Seven donated shipping containers that once ferried ice cream and frozen vegetables around the world, now house a most precious collection of endangered Panamanian frogs—often the sole survivors of their species. The new world-class facility enables us to more effectively tackle the amphibian conservation crisis. Since 2006, patient researchers have successfully bred and raised 18 Panamanian amphibian species to adulthood including the iconic Golden Frog. This is a major milestone for conservation efforts, and one worth celebrating. The center sponsors an annual Golden Frog Festival, with events throughout Panama that unite locals and visitors from around the world in a single mission: celebrating and conserving Panama's amphibian treasures.

The Smithsonian is engaged in conservation at all levels. For the past year scientists at the Smithsonian Conservation Biology Institute (SCBI) have been working with aviation and aerospace leaders, led by Airbus Americas, Inc., to launch the "Partners in the Sky" program using aviation and aerospace technology to create a first-of-its-kind global animal tracking system.

We are also engaged in the interdisciplinary field of conservation medicine, which integrates veterinary medicine and environmental science. Zoonotic diseases are contagious diseases spread between animals and humans, caused by bacteria, viruses, parasites, and fungi that are carried by animals and insects. Examples are Avian Influenza, HIV/AIDS, SARS, often Influenza H1N1, Lyme disease, malaria, and West Nile virus infection. The CDC reports about 75% of recently emerging infectious diseases affecting humans are diseases of animal origin, and approximately 60% of all human pathogens are zoonotic. In the context of modern globalization, these diseases can travel very quickly, posing serious public health, development and economic concerns.

To respond to zoonotic disease threats, University of California Davis, Eco health Alliance, MetaBiota, Wildlife Conservation Society and Smithsonian are part of a USAID-funded program called PREDICT. The PREDICT project seeks to identify new emerging infectious diseases that could become a threat to human health. PREDICT partners locate their research in geographic "hotspots" and focus on wildlife that are most likely to carry zoonotic diseases—animals such as bats, rodents, and nonhuman primates.

PREDICT has compiled the most comprehensive data on the risk of zoonotic disease emergence throughout the world and a highly refined global risk map. PREDICT also ventures across the world to support local researchers and actively builds local capacity. To conduct surveillance in wildlife for zoonotic pathogens, a basic level of in-country capacity is needed. Field samples must be collected, transported to diagnostic labs and analyzed for identification of known and novel pathogens. Through PREDICT, more than 1,600 people in 20 countries have been trained in these roles, creating an extensive field and laboratory infrastructure, and a substantial, long-term wildlife surveillance footprint.

PREDICT partners work with scientists and policymakers in each country to create a network of research, communication, and response partners on a local, regional, and global level. For example, PREDICT helped identify and respond to a Yellow Fever outbreak in March 2012 after five howler monkey carcasses were found near a wildlife sanctuary in eastern Bolivia. The PREDICT network responded quickly. DNA sequencing confirmed that the infections had been caused by two Yellow Fever viral strains, both of which were related to human cases in Trinidad and Tobago and Brazil.

Only eight days passed between the onset of outbreak and notification of the Bolivian government. Preventive measures were promptly implemented in the

affected area, including vaccination campaigns, public outreach and mosquito control. Thanks in part to the fast response no human cases occurred during the outbreak.

Invasive species and ecosystem protection

One of the acknowledged environmental impacts of speedy international commerce and travel is the spread of invasive species. Many parts of the U.S. government monitor and protect our land and shores as much as possible. Our natural history collections are used for identification, and long-term partnership between the Smithsonian Environmental Research Center (SERC) and the Coast Guard has developed a program that contributes key data and information about coastal and marine invasive species.

Ballast water is a vector for marine species throughout the world. Biological Invasions (the movement of species beyond their historical range) are a major force of ecological and evolutionary change. These invasions have increased dramatically in recent time, and their impacts dramatically change the structure of ecosystems around the world. That change, in turn, impacts many dimensions of human society.

SERC is actively evaluating the national status and trends of invasive species in our coastal marine ecosystems. This includes ongoing field surveys of ships' ballast water and hulls for invasive species that make their way from one ocean to another. SERC's research program investigates several different facets of ballast-mediated invasions including: (1) the abundance, diversity, and dynamics of organisms in ballast tanks and (2) the effectiveness of management tools used to slow the rate of invasion due to ballast water discharge.

SERC has also partnered with the United States Coast Guard on a joint program called the National Ballast Information Clearinghouse (NBIC) in which they collect, analyze, and interpret data on the delivery of ballast water and the management practices of commercial ships that operate in the waters of the United States. The NBIC characterizes ballast water practices for over 100,000 commercial ship arrivals to US ports each year.

More broadly, the NBIC seeks to understand biological invasion patterns and processes in marine ecosystems. NBIC characterizes patterns of marine invasion across space, time, and taxonomic groups for over 500 species that have colonized US waters. NBIC uses these data to identify factors that drive invasions and enhance the nation's predictive capability about the spread and impacts of non-native species in marine ecosystems. Both the ballast data and invasion data are made available as a public resource, online.

One of the most interesting aspects of our collaborative work is documenting the occurrence of pathogens (of humans and marine wildlife) in ballast water. This includes various bacteria and protists, and it suggests a possible role of this

transport in epidemiology and disease outbreaks—especially for marine wildlife. While a fair amount is known about transfers of larger organisms, like macroinvertebrates (crustaceans, molluscs, etc), relatively little is known yet about the diversity and consequences of microorganism transfers.

UNLOCKING THE MYSTERIES OF THE UNIVERSE

The Smithsonian Astrophysical Observatory (SAO), the National Air and Space Museum (NASM) and the National Museum of Natural History (NMNH) focus on applying the integrative research to today's big questions regarding the origin and evolution of the Earth, planets, stars, galaxies, and the universe.

Areas of specific focus include the study of the origin and evolution of the Earth and solar system; the effects of geologic and meteoric phenomena on Earth's atmosphere and biosphere; research into the discovery and characterization of exo-planets in the habitable zone; research using our rich collections, including the national meteorite collection; and research into the next generation of ground- and space-based astronomical telescope mirrors and instrumentation that will enable the next generation of research.

SAO's partnership with Harvard University to form the Harvard-Smithsonian Center for Astrophysics has, since 1973, grown to be the most powerful astronomical program in the world. SAO is the largest Smithsonian unit with 900 employees who staff observatories in Arizona and Hawaii, and partner in Chile with universities throughout the United States and abroad to include Harvard, Arizona, University of Chicago, University of Texas, Texas A&M, and the Carnegie Institution for Science, and universities in South Korea, Australia, and Taiwan among many other collaborators.

SAO's pioneering efforts in the development of orbiting observatories and large ground-based telescopes, in the application of computers to astrophysical problems, and in the integration of laboratory measurements, theoretical astrophysics, and observations across the electromagnetic spectrum have contributed greatly to unveiling the secrets of the universe. These efforts have principally been supported by competitively awarded contracts and grants from NASA and NSF buttressed by our federal appropriation. From studying planets around other stars to charting galaxies moving at almost the speed of light, SAO scientists remain dedicated to the increase of knowledge about those physical processes that shape the natural world, and to the diffusion of this knowledge to the scientific community, to teachers and students, and to the general public.

SAO's research spans from studies of the characteristics of the solar environment to studies on the origins of the universe among many other topics, including the intriguing search for habitable planets. Instrumentation development is a great strength of SAO. Armed with that prowess, SAO has been called on by NASA to collaborate on some of the most prominent research investments of our time:

TEMPO

In November 2012, SAO was selected by NASA to build the Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument, the first space-based instrument to monitor major air pollutants across North America, from Mexico City to the Canadian tar sands and from the Atlantic to the Pacific, hourly and at high spatial resolution. TEMPO will be launched into a geostationary orbit in 2017 and will become part of a global constellation of satellites that include missions from Europe and Asia to monitor air quality.

Chandra

In July, Chandra, NASA's flagship mission for X-ray astronomy began its 15th year of operation. SAO hosts the Chandra X-ray Center that operates the satellite, processes the observations and distributes the data to scientists around the world for analysis.

Recently, Chandra has made exciting new discoveries in a variety of fields of astrophysics, from planets around other stars (known as "exoplanets"), to the birth and death of stars, to giant black holes in the centers of galaxies, and to clusters of galaxies, the largest objects in the universe held together by gravity. For example, astronomers used Chandra to show that the remains from the explosion of a star may contain the most recent black hole formed in the Milky Way galaxy. Chandra was also used to take a major step in explaining why material around the giant black hole at the center of the Milky Way galaxy is extraordinarily faint in X-rays, a discovery that holds important implications for understanding the growth of the biggest black holes. Closer to home, X-ray observations from Chandra have detected an exoplanet passing in front of its parent star, the first X-ray transit observed since exoplanets were discovered almost 20 years ago. This transit teaches us about the atmosphere of this distant world.

On the much larger scales of the Bullet Cluster, Chandra and other observatories were used to show for the first time that dark matter, a mysterious invisible substance, can be separated from normal matter when clusters of galaxies collide. This provides direct evidence for the existence of dark matter. Similar objects might be observed in a collaborative program called the Frontier Fields, where Chandra observations, along with Hubble Space Telescope and Spitzer Space Telescope observations have been planned to look deep into the early Universe. Astronomers will observe enormous clusters of galaxies, exploiting a phenomenon known as gravitational lensing, to learn about very distant galaxies whose light is magnified and brightened as it passes through a massive cluster. The Chandra observations will image the hot gas in the clusters, to help determine whether it remains close to the galaxies and dark matter, or is stripped away by collisions, as in the Bullet Cluster.

Center for Earth and Planetary Studies

Through research and direct involvement in active planetary missions, scientists in the National Air and Space Museum's Center for Earth and Planetary Studies (CEPS) seek to expand our knowledge of geologic processes across our solar system and how these processes may contribute to habitable conditions on other planets.

CEPS scientists are on the teams of NASA's Mars Science Laboratory (Curiosity) rover, the Mars Reconnaissance Orbiter, the Lunar Reconnaissance Orbiter, and the MESSENGER mission to Mercury. Other CEPS scientists conduct research on the Earth, Venus, and asteroids.

CEPS scientists study the rocky planets in our solar system and beyond, to gain insight into the geologic evolution of the Earth and Earth-like planets. For example, CEPS scientists used radar sounder data from the SHARAD instrument on the Mars Reconnaissance Orbiter to construction the first three-dimensional views of buried young channels on Mars formed by gigantic floods due to the catastrophic eruption of groundwater. The results were published in the journal *Science*.

During its second and final extended mission, the MESSENGER spacecraft's orbit around Mercury will be changed to allow very high resolution imaging of the surface that was not possible before. CEPS scientists will lead the effort to search for evidence of small-scale faults that cannot be detected in the current orbit. These faults may be evidence of very recent, and possibly current, tectonic activity on Mercury.

In November 2011, a geologist at NASM was selected by NASA to be a Participating Scientist on the Mars Science Laboratory Curiosity mission. Since *Curiosity* landed in August, 2012, he has served as a Long Term Planner charged with working to establish the strategic goals and plans for the science team and rover. He also works with data from Curiosity to understand the processes responsible for shaping the landing site in Gale crater. Scientific papers describing results from Curiosity were published in Science in December 2013, including 4 co-authored by this CEPS participant. These papers describe evidence for past environments on the floor of Gale crater that could have been habitable. Moreover, results include some of the first absolute age dating of surfaces on Mars and show that these habitable environments persisted until ~3.5-3.0 billion years ago, younger than had been previously assumed for Mars.

SAO/NASA Astrophysics Data System

We also help to connect scholars to information to expand knowledge. The SAO/NASA Astrophysics Data System (ADS) is a network of online portals to astronomical literature that spans from Jakarta to Kiev, from Munich to Beijing. ADS recently celebrated its twentieth anniversary of providing free, open digital access

to the entire archive of astronomical publications, some going back to the early 1800s. The ADS corpus consists of 10 million bibliographic records, 60 million citations, and nearly 3 million full-text documents—the world's most complete collection of scholarly content in the physical sciences.

More researchers now read more content through ADS than through all astronomy libraries in the world combined. With nearly 10 million different visitors annually, ADS is a key provider of astronomical publications to both professional scientists and the general public. The UN General Assembly recognized that "the mirror sites of the NASA-funded Astrophysics Data System (ADS) . . . had become important assets for developing countries ..." by providing free access to the scientific literature for those not able to afford costly subscriptions.

ADS embodies the principles and goals of Smithsonian's mission to increase and diffuse knowledge. ADS is a pioneer in utilizing digital tools to rapidly ingest and disseminate the scientific literature, to serve the world community of scientists and interested public, and to set an example of balancing the needs of publishers and the open community of scholars.

Meteorites

The Antarctic Meteorite Program is a cooperative agreement between the National Science Foundation, NASA, and the Smithsonian to provide for the collection, curation, distribution, and long-term storage of meteorites recovered during annual U.S. expeditions to Antarctica. Returning more meteorites in the last 30 years than were collected over the entire Earth in the previous 500 years, the Antarctic Search for Meteorites (ANSMET) is an inexpensive yet guaranteed way to recover meteorites from the Moon, Mars, and previously un-sampled asteroids. These rocks are critical to our understanding of the history of the Solar System, providing essential "ground-truth" for our study of the asteroids, planets, and other bodies of our solar system.

Small meteor fragments fall from the sky frequently, but the idea of more substantial objects impacting Earth makes frightening headlines in the popular media. Rest assured, the Smithsonian is doing its part to keep you safe. The Smithsonian Astrophysical Observatory houses the Minor Planet Center (MPC), a single worldwide location for receipt and distribution of positional measurements of minor planets, comets and outer irregular natural satellites of the major planets. The MPC is responsible for the identification, designation and orbit computation for all of these objects. Funded by NASA, the MPC receives observations of transient objects, computes their orbits, communicates with observers and warns of impending impacts. An impact detection scale shows we should be safe from the objects we know about for the next 100 years or so. In the mean time, SAO and the MPC will continue to collect and disseminate data on existing and newly discovered objects that might pose a hazard to Earth.

Giant Magellan Telescope

Beyond NASA, the Giant Magellan Telescope (GMT), is a next-generation ground-based telescope, is being built collaboratively by an international consortium of 10 leading universities and science institutions, including the Smithsonian Astrophysical Observatory. The first 8.4-meter mirror segment has been completed, thus retiring a key technical risk to the project. SAO is building the first focal-plane instrument to be commissioned during the Phase 1 science operations, scheduled to begin in 2019. This 10-ton instrument, G-CLEF, is an extremely versatile fiber-fed spectrograph with the capability of detecting Earth-sized planets in the habitable zone around stars like our Sun.

"Time and Navigation"

We also bring these activities back to our visitors. The exhibition "Time and Navigation" opened last spring at the National Air and Space Museum (NASM) and explores the connections between place and time. Whether you are using a smartphone to locate a destination or a sextant and stars to navigate the oceans, you need an accurate clock to determine where you are. "Time and Navigation," developed by NASM and the National Museum of Natural History, takes the visitor (both in the museum and on-line) through the history of "getting from here to there," showing how early navigators needed special training and equipment, while today's travelers rely heavily on a suite of more than 30 Earth-orbiting satellites that carry atomic clocks and form the Global Positioning System (GPS).

EDUCATING THE NEXT GENERATION

The Smithsonian asks and answers questions about science, art, history and culture, exciting the learning in everyone, every day.

Much of the Smithsonian's research is aimed at understanding and sharing information about scientific questions that are as yet unresolved. Critical to this multi-faceted approach is inspiring, training and educating the next generation of scientists.

Smithsonian offers top internships and fellowships

The Smithsonian extends its educational capacity to improve scientific literacy through fellowships and internships in every discipline. Smithsonian Fellowships offer opportunities to visiting professionals and scholars for independent study and research with a Smithsonian advisor that makes use of Smithsonian collections and research facilities. Across all disciplines, the Smithsonian hosted 745 fellows this year who represented 51 countries and 37 states, DC and PR. Smithsonian also hosted 1,339 interns this year from 38 countries and 42 states, DC, USVI and PR. In

Fiscal Year 13, Smithsonian also hosted 539 research associates from 13 countries and 300 universities. While these figures reflect a pan-Institutional educational endeavor, our science units host the most students. Fellows flock to NMNH, SAO, NZP, and STRI where they frequently stay or return as research associates. The Smithsonian mentors and trains the next generation of researchers and scholars.

Conservation education

The National Zoo's Smithsonian Conservation Biology Institute (SCBI) provides a variety of training and capacity building programs for students and professional audiences, specifically targeting individuals and institutions from developing countries and underserved communities.

SCBI scientists and research associates have taught training courses in the United States and at more than 20 international locations for over three decades, reaching nearly 6,000 individuals from more than 116 countries.

Here at home, through a partnership with George Mason University, the Smithsonian-Mason School of Conservation (SMSC) was built to engage undergraduates, graduate students and professionals from around the world in a range of compelling, transdisciplinary programs in conservation biology. The participants thrive in an atmosphere of creative, critical and analytic thinking on how to search solutions to some of the most intractable conservation problems facing society today. The School's integrated approach unfolds in a modern, innovative gold LEED-certified educational facility within the 3,200-acre SCBI. The SMSC is rapidly becoming a benchmark for innovative education for current and future generations of conservation biologists, policymakers, and global conservation leaders.

Smithsonian Science Education Center

Twenty-eight years ago, the Smithsonian Institution and the National Academies jointly established the National Science Resources Center (NSRC). These widely respected scientific institutions provided a unique platform and the resources to catalyze change at all levels of the education system. In 2010, Secretary Clough created the Smithsonian Office of Education and Access, which is charged with coordinating all K-12 educational programs throughout the Smithsonian. As an integral part of this focused education initiative, the NSRC was fully integrated into the Smithsonian and is now known as the Smithsonian Science Education Center (SSEC). SSEC is uniquely positioned to bring all of the cutting edge science from the world's largest museum and research complex to children in the classroom. SSEC is nationally and internationally recognized for the quality and impact of its programs on K–12 science education.

Our expertise and experience as a research Institution and as an educational Institution coupled with our international reach and ability to convene stakeholders uniquely positions us to take on global challenges.

Museum-based education and outreach

The Smithsonian seeks to bring content experts and educators together to help strengthen American science education. The Smithsonian serves as a laboratory to create models and methods of innovative informal education and link them to the formal education system. As the Secretary detailed, Q?rius is a first-of-its-kind interactive and experimental environment, and we have other learn-by-doing activities in all of the museums.

The Smithsonian has a variety of content, resources, and educational materials spread across its website and those of our museums for learners of all ages. Museum educators offer several virtual learning experiences to students across the globe.

For example, the National Air and Space Museum offers an abundance of science-focused programs. Museum "Explainers" conduct demonstrations daily on the science of flight in the *How Things Fly* gallery. Lecture series feature scientists and astronomers from around the country. At the Udvar-Hazy Center, children learn about a variety of aviation- and space-related topics at the monthly Super Science Saturdays. Science subjects are often the topic of discussion at the Museum's Ask Expert talks, and the youngest children learn by listening to "Flights of Fancy" stories. In addition, a regular series of Family Days takes place, offering themes such as exploring the universe, planetary studies, and space exploration.

The Science Education Department (SED) of SAO develops curricula and materials that reflect current scientific and educational philosophy. The center plays a leading role in the study of the nature of learning. Major projects include the development of misconception-based assessment instruments, and research into identifying measurable factors that predict levels of achievement. SED research and materials are widely available online and in print, and at workshops and teacher conferences. Through its efforts, the SED aims to advance the public's understanding of astronomy and the physical sciences.

The Smithsonian is an active partner in the broader efforts to coordinate STEM efforts across the federal government. We have worked closely with agencies such as NASA, NIH, NOAA and the U.S. Forest Service to improve programming at our own museums, better inform their outreach, and on joint initiatives such as Waterways, a project that increases individual awareness about the environment and eco-stewardship.

Conclusion

On land, water or beyond our atmosphere, Smithsonian science is engaged in the world's greatest challenges. Whether they are protecting ecosystems that are threatened, discovering new planets, or assessing the consequences of environmental change, Smithsonian scientists apply what they learn to improve the quality of life on Earth and to understand our place in the universe. We broaden access and reach new audiences by bringing the resources of our museums and research centers to people where they learn and live. The collections are our window on the past and our legacy for the future. Smithsonian is paramount for protecting this legacy for reanalysis and new understanding. As stewards, scholars, collaborators and conveners, the Smithsonian strives to address important issues in science today and improve the lives of all Americans.

Eva J. Pell
Under Secretary for Science

Eva J. Pell, Under Secretary for Science, joined the Smithsonian Institution in January 2010. She oversees the operations of the National Museum of Natural History; the National Air and Space Museum; the National Zoo and its Conservation Biology Institute in Front Royal, Va.; the Smithsonian Astrophysical Observatory in Cambridge, Mass.; the Smithsonian Environmental Research Center in Edgewater, Md.; the Smithsonian's Museum Conservation Institute in Suitland, Md.; and the Smithsonian Tropical Research Institute in Panama.

Dr. Pell earned a B.S. in biology from City College of the City University of New York in 1968, and a Ph.D. in Plant Biology from Rutgers University in 1972. In 1973, Dr. Pell was appointed as an Assistant Professor of Plant Pathology at the Pennsylvania State University. There she rose through the ranks and was named Distinguished Professor of Plant Pathology in 1991, and in 1995 was named the John and Nancy Steimer Professor of Agricultural Sciences. Dr. Pell's research focused on the impact of air pollutants on vegetation and her research spanned from the molecular to the ecophysiological. In recognition of leadership in her field in 2003, Dr. Pell was elected as a Fellow of the American Association for the Advancement of Science (AAAS). In January 2000, Dr. Pell was appointed Vice President for Research and Dean of the Graduate School at Penn State University and on May 12, 2006, the Board of Trustees approved the recommendation for her title change to Senior Vice President for Research and Dean of the Graduate School, a position she held until December 31, 2009. In her years as senior research officer and graduate dean, Dr. Pell served on numerous national committees and organizations. Dr. Pell was the 2003-2004 President of the American Association of Universities' Association of Graduate Schools and was chair of the Association of Public and Land-grant Universities' Council of Research Policy and Graduate Education from 2004-2005.

Chairman BUCSHON. Thank you very much. I was interested in the word snarge. It is one of those words that kind of sounds like what it is, kind of, you know—I now recognize Dr. Johnson for five minutes to present his testimony.

TESTIMONY OF DR. KIRK JOHNSON, DIRECTOR, NATIONAL MUSEUM OF NATURAL HISTORY

Dr. JOHNSON. Thank you, Mr. Chairman.

I am going to talk today about the research, the collections, and the public impact of just one of the Smithsonian museums, the National Museum of Natural History. This is the largest of the museums. Not only is it the largest Smithsonian Museum, but it is also the largest natural history museum in the world by far. At the Natural History Museum, we really do only three things. We do basic scientific research, we guard and use the Nation's science collections, and we inspire and educate our public who knows they learn best when they are having a social and fun time with their families.

We have more than 7 million visitors each year at the National Museum of Natural History, which is an amazing number. It is the most-visited museum in the world. And 84 percent of our visitors come from out of town, which means they are unique visitors, which means every year we get a different 84 percent of 7 million which means in a decade we might see as many as 60 million people in that one building on the National Mall. That makes us the premier science education space in the world and it means that something like 20 percent of the American population will walk into that building every decade. So it is a phenomenal asset for communicating about the natural world.

We also have more than 90 percent of the Smithsonian's collections with 127 million objects, specimens, and artifacts. And this is where we keep the objects that we treasure about the world and study those objects. We have 11,000 scientists who visit us each year to study those objects here in our facility in Suitland, Maryland. We are the home to the iconic Hope Diamond, and we are the real Jurassic Park.

With more than 200 scientists, we have the largest museum science staff in the world, and these are scientists who have three primary areas of expertise: the study of Earth and similar planets, the study of the diversity of life on Earth, and the study of human diversity and cultural change. They publish more than 600 scientific books and papers every year often describing new species and making discoveries about plants, animals, and organisms around the world.

Also embedded in the Natural History Museum, we have scientists from the U.S. Department of Agriculture, from the U.S. Geological Survey, from the Department of Defense, and from NOAA's National Marine Fisheries Service. They are there because our collections allow them to do the work they need to do, things like preventing our troops from getting malaria, things like preventing invasive pests from crossing our borders, and understanding the vulnerabilities of our fishery stocks.

Today, we had a number of scientists here. I will just mention two of them. Dr. Tim McCoy is the Chair of the Mineral Science

Department. He studies meteorites. And if you ask him why he studies meteorites he will say, well, I want to understand the formation of the solar system, which seems a little bit ethereal to a lot of us. It is a very important topic but you have to think back in February, just a year ago in Russia when the Chelyabinsk meteorite exploded over Russia, there was a meteorite the size of a bus traveling at five miles a second that, depending on how it came in, could cause a tremendous amount of damage. We know that a six-mile-diameter asteroid is probably what caused the extinction of dinosaurs and most life on Earth 66 million years ago. So these things are real and they are in our time frame and we need to understand them, and that happens at a place where we have the world's collections of meteorites.

You saw the work of Dr. Kris Helgen, who is a mammalogist, who at a very young age has discovered dozens of new species of previously undescribed mammals by looking at collections and visiting natural habitats around the world.

These experts represent a dedicated staff but they are also the inspiration for what we present to the public as our various exhibits.

In this last year, we partnered with the National Human Genome Research Institute at the National Institutes of Health to put together an exhibit called Genome: Unlocking Life's Code. This is in celebration of the 60th anniversary of Watson and Crick's discovery of the double helix structure of DNA and the 10th anniversary of the discovery of the decoding of the human genome. And this is one of these very rapidly evolving fields in science and medicine where we are all real interested in what is going to happen, and a really good place to get started learning about it is to come down and see the exhibit on the Mall.

In December we opened a 10,000 square-foot exhibit called Q?rius, and this is a place where we have turned the museum inside out and made our collections, our scientists, and our scientific equipment available to primarily teenagers because we know that people will study things if they are very interested in them. And we find that museums are a great way to catalyze people's curiosity.

We will be opening in a few years a complete renovation of the Nation's Fossil Halls, which originally opened in 1911 as the Hall Of Extinct Monsters. In the last century we have learned so much about the history of the Earth and the story of dinosaurs that we are going to be renovating that entire space. And later this spring we will be bringing to Washington, D.C., a complete real Tyrannosaurus rex in partnership with the U.S. Army Corps of Engineers and the Museum of the Rockies. It will be the first real Tyrannosaurus rex in the Nation, the Nation's T-rex in Washington, D.C., and we will use that to launch our renovation, which will open in 2019.

So as you can see, the Natural History Museum is a curiously successful blend of three very different things: very serious science, our treasured objects, and a deeply engaged public that is learning while it is having fun. Thank you very much.

[The prepared statement of Dr. Johnson follows:]

U.S. House of Representatives
Committee on Science, Space and Technology
Subcommittee on Research and Technology

Testimony of Dr. Kirk Johnson
Director, National Museum of Natural History
Smithsonian Institution

January 14, 2014

Introduction

Thank you, Mr. Chairman and distinguished members of the Subcommittee. It is an honor to appear before the Subcommittee to discuss scientific research, collections and the public impact of the Smithsonian's National Museum of Natural History (NMNH). My name is Kirk Johnson and I have served as Sant Director at the National Museum of Natural History since October 2012.

The Smithsonian's National Museum of Natural History houses most of the founding collections of the Smithsonian Institution. Over the last 167 years, these collections have grown to include more than 127 million objects, specimens, and artifacts, and have become the largest and most comprehensive sample of the Earth's diversity. These collections are an irreplaceable scientific tool that is used by more than 11,000 scientists each year. With nearly 8 million visitors in 2013 alone, NMNH is also the most popular natural history museum in the world.

Visitors of all ages come to the Museum from across the nation and around the world because they are curious about the natural world and because they want to see things that can only be seen in a museum of this size and scope. They come to see the dazzling Hope Diamond and to be in the presence of the real Jurassic Park. They come to understand meteorites, to learn how gemstones form, to discover the causes of earthquakes and tsunamis, to see live rainforest butterflies, to understand the deep history of humanity, and to share engaging and exciting learning experiences with family and friends. More is on the way as a spectacular *Tyrannosaurus rex* (T. rex) fossil from Montana will be transported to the Museum this year to anchor our new National Fossil Hall.

In the past, most of our visitors have been unaware that our exhibitions and public programs are just the tip of the iceberg and that there is a vast scientific research enterprise operating behind the scenes. In order to make our experts and their work more accessible to students, parents and teachers, we have just opened a new 10,000-square-foot learning center that we call *Q?rius* (pronounced "curious"). Seven years in the making, *Q?rius* is both a place and an experience, a new way for teens– and their families and educators – to connect science with everyday life. In *Q?rius*, the full range of our science and collections will be directly accessible to our huge public audience in a way that is interactive and hands-on. Students and teachers outside our nation's

capital will have easy access to much of what we offer through a menu of online and digital outreach options.

This Museum belongs to each and every American, and stands as a vital resource for scientists and a window into the natural world for millions of people each year. Nurturing and expanding the work and educational reach of the National Museum of Natural History is an investment in our nation's future.

We thank the Chairman and this Committee for their steadfast interest and support. I now wish to provide the committee with background on the Museum, discuss recent accomplishments and address some of the issues and challenges we will face in the future.

Scientific Research and Collections

Science is the foundation of the National Museum of Natural History and, in many respects, of the Smithsonian Institution, itself. The Museum currently supports collection-based research in three thematic areas: the formation and evolution of the Earth and similar planets; the discovery and understanding of life's diversity; and the study of human diversity and cultural change.

NMNH is organized into seven departments: anthropology, botany, entomology, mineral sciences, invertebrate zoology, paleobiology, and vertebrate zoology. We have on staff 84 scientists—including the largest concentration of biodiversity scientists on Earth. Our scientists travel to ocean depths, the peaks of the Andes, Africa's Rift Valley, the rainforests of South America, and the deserts of Central Asia, and of course, to every area of our own nation. They are routinely evaluated by their peers as world experts in their field. Four members of the National Academy of Sciences are currently on the NMNH staff. These scholars and approximately 200 postdoctoral or resident researchers, produce, on average, 600-700 scholarly publications per year. Over the Museum's history, our scientists have published more than 40,000 books and articles and, in so doing, have made a profound contribution of our collective understanding of the natural world.

NMNH scientists collaborate with universities and research centers in every state in the nation and conduct research in more than 80 countries around the world. Scientists from around the world visit the NMNH to access our collections and scholars. Last year we hosted more than 11,000 distinct research visitors to our collections, for a total of 25-30,000 visitor days. They come here in such great numbers because our scientists and collections are a unique scientific resource. In addition to hosting scholars that come to Washington to research our collections, we also travel these resources. At any given time, over two million NMNH objects are on loan to national and international research organizations. As a result of these activities, Smithsonian natural history collections are cited in more than 1,200 (non-Smithsonian authored) scientific publications annually.

In addition to their basic research, our scientists also train the next generation of scientists. In just the last fiscal year, NMNH training reached 743 academic appointments, 374 citizen scientist volunteers, 465 interns, and 254 research students and postdoctoral researchers.

The 1846 legislation that created the Smithsonian Institution identified the U.S. National Museum (as the NMNH was originally known) as the repository for natural history specimens belonging to the United States:

> "All collections of rocks, minerals, soils, fossils, and objects of natural history, archaeology, and ethnology, made by the National Ocean Survey, the United States Geological Survey, or by any other parties for the Government of the United States, when no longer needed for investigations in progress shall be deposited in the National Museum" (20 U.S.C. § 59).

That role of steward of the U.S collections has been emphasized by legislation, and evidenced by the steady growth and diversification of the collections. The Smithsonian is honored to ensure these precious holdings and shared vital research infrastructure are preserved and strengthened for the benefit of both our country and the global scientific research enterprise.

We work in partnership with several federal bureaus to advance the impact of federally-funded science. Affiliated U.S. government agencies contribute immeasurably to the Museum's strength as a research center and depend heavily on our collections in conducting research. Several of them house their collections and scientific staff at the NMNH. These include the Department of Interior (the Fish and Wildlife Service and the U.S. Geological Survey), the Department of Agriculture (the Systematic Entomology Laboratory), the Department of Commerce (the National Marine Fisheries Service Systematics Laboratory), the National Oceanic and Atmospheric Administration, and the Department of Defense (Walter Reed Biosystematics Unit). Some 50 professionals from other federal agencies work full time at NMNH because our science and collections are vital to their applied missions.

Our interagency collaboration also extends to ensure a systematic approach to safeguarding scientific collections under the stewardship of the federal government. As recognized by the America COMPETES Act of 2010, the proper management, documentation, preservation, and accessibility of collections are critical to the nation's research and education infrastructure. The preservation and management of Federal scientific collections is recognized as part of the long-term infrastructure needs and responsibilities of Federal scientific agencies. The Museum serves as a leader in the Federal community by the excellent progress we have made and the professional standards we establish in collections management to ensure all scientific, cultural and historical collections are preserved and remain accessible for current and future generations. We prioritize our collection care efforts using four key collection metrics (condition, information content, importance, and outreach potential) and use this approach to continually improve the quality of the collection. Taken together, these efforts have produced the largest, most comprehensive natural history collection in the world.

Collection-based research plays a vital role in addressing contemporary challenges. NMNH scientists and their colleagues worldwide seek the puzzle pieces that will form detailed pictures of vital topics such as evolutionary relationships of organisms, biodiversity loss and global change. The collections' relevance to science and society continues to grow and evolve as new technologies are applied to their study and analysis.

For our presentation to Subcommittee we have brought a few objects and the scientists who study them as examples of how collection-based scientific research is relevant to the concerns of society today.

1. Bird-strikes and airplanes: The research of Dr. Carla Dove

   When US Airways Flight 1549 landed in the Hudson River on January 15, 2009, the world became even more aware of the hazards that birds can cause to flight safety. What many people did not realize was that for more than 50 years researchers at the National Museum of Natural History have been working behind the scenes to provide data to the Federal Aviation Administration (FAA), the U.S. Air Force and Navy, and to engine manufacturers such as General Electric and Pratt & Whitney, regarding the species identifications and weights of birds that are struck by aircraft. Knowing the natural history of problematic species will help reduce the damaging costs of bird-strikes on airfield environments and improve aviation safety.

   Currently, the FAA reports nearly $500 million in damages annually from bird-strikes and last year alone the United States Air Force suffered three Class A bird-strikes (incidents that resulted in loss of life or more than $2 million in damage).

   So, when Captain Chesley "Sully" Sullenberger made his emergency landing into the Hudson River on that cold January day, highly trained researchers at the Smithsonian were ready to investigate. The first feathers pulled from the engines were hand-carried to the Museum by United States Department of Agriculture colleagues. Scientists at the Museum's Feather Identification Lab used DNA barcoding methods and stable hydrogen isotope analysis to identify the species as Canada Goose, and determined that the birds were from a migratory population rather than resident birds.

   This information highlights the need to focus future research on bird migration patterns while maintaining the current wildlife management strategies on airfields. Museum scientists have identified the following issues and concerns:

   - Since 1988, civil aviation reports 231 people have been killed as a result of bird strikes, with more than 220 aircraft destroyed.
   - United States Air Force reports over 4,500 bird-strikes each year
   - Large birds such as Canada Geese, Bald Eagles, White Pelicans, Black Vultures, cause the most damage and are increasing in population numbers
   - Since the Hudson River event, the Smithsonian's Feather Identification Lab has experienced a 146% increase in identification case-work from civil aviation alone.
   - FAA does not require bird-strike reporting, or that remains be identified. We estimate that only about 25% of the strikes are linked to the type of bird that caused them.

2. Meteorites and Fireballs: The research of Dr. Tim McCoy

   The explosion of the Chelyabinsk meteorite over Russia on February 15, 2013 was marked by a spectacular fireball recorded by dashboard cameras. The sonic boom burst windows on the ground and injured hundreds of people. The meteorite that produced this fell as thousands of stones, the largest of which was only recently recovered from a lake bottom and weighs nearly half a ton. Smithsonian scientists acquired samples of the meteorite and continue to

study these and similar stones to understand their remarkable history from the birth of the Solar System 4.5 billion years ago to the danger that they pose to society today.

3. Three-Dimensional Printing and Fossil Whales: The research of Dr. Nick Pyenson.

   This scale 3D print shows the skeleton of a 7 million year old whale. Smithsonian and Chilean scientists scanned the original skeleton only days before the site where it was found was bulldozed to expand the Pan-American Highway. The three-dimensional data now provides an exact record of the skeleton, as it was originally found, for future generations to study. This technique allowed for construction to proceed without the loss of a scientifically important discovery.

4. A new species of mammal discovered in 2013: The research of Dr. Kristofer Helgen

   The olinguito (*Bassaricyon neblina*) is the smallest member of the raccoon family and the first new species of carnivore discovered in the Americas in 35 years. Curator Kristofer Helgen and his team used data from overlooked museum specimens to describe this new mammal and to find and study it in the wild in the Andes Mountains. The discovery of the olinguito has drawn global attention to the Andes' endangered cloud forest habitats, illuminates the fundamental scientific importance of museum collections, and shows how much of the biological world remains to be explored by scientists.

Exhibitions, Education, and Outreach

Science will inform solutions to many of the environmental, health and economic challenges of our time. Yet America faces a deficit of scientific understanding. In a 2009 international assessment of scientific literacy, American high school students ranked behind their peers from 12 other developed nations. Only 1% of our 12th graders are performing at an advanced level in science. In fact, most are failing to reach the proficient level in science, as determined by the National Assessment of Educational Progress.

As the most visited natural history museum in the world, we have the opportunity and responsibility to ignite the minds of the next generation of STEM (Science, Technology, Engineering, and Mathematics) professionals; and inspire lifetime learners to discover the science behind current environmental issues that affect our daily lives.

We presently welcome 8 million annual visitors – and many millions more online. A recent visitor survey revealed that 84 percent of our visitors are visitors to Washington, D. C. New information and social media technologies enable us to reach broader audiences, and online information now accompanies all major exhibitions. As a result, the number of online visits to the Museum's websites and social media followers continues to increase and we are able to reach an even broader audience. We also collaborate with the Smithsonian Channel, Smithsonian Magazine, and other media outlets to introduce our collections and experts into homes across the country and the world.

From the sea creatures in the Sant Ocean Hall to the iconic Hope Diamond in the Janet Annenberg Hooker Hall of Geology, Gems and Minerals, the Museum combines cultural artifacts and specimens with engaging stories and innovative technology to connect visitors to

stories of the natural world and its peoples. Our exhibitions invite visitors to ask questions and to explore answers using evidence, objects and interactive experiences. Responsive to our rapidly changing world, our exhibitions showcase topical science by our own researchers and our many partners. The exhibitions provoke discovery and inquiry, and encourage an appreciation of the natural and cultural processes that shape our world.

Anchoring the Museum are exhibitions that delve into the science of such complex and far-reaching topics as the history and dynamics of Earth and other planets; the evolution, diversity, and interdependence of life; and human evolution, diversity and culture. The Sant Ocean Hall communicates the critical message that the ocean is a global ecosystem essential to all life on our planet, including our own. In the David H. Koch Hall of Human Origins, visitors can walk through six million years of humans' evolutionary history and explore how dramatic climate change drove evolution of the characteristics that make us human. Visitors can get to know more than 60 of our mammal relatives in the Kenneth E. Behring Family Hall of Mammals.

We are just beginning a complete renovation of our National Fossil Hall, where the popular dinosaur fossils are housed. It is one of the Museum's most ambitious projects yet and the resulting exhibition will leverage our understanding of the Earth's past to inform our choices about its future. A centerpiece of the new National Fossil Hall will be a spectacular *Tyrannosaurus rex* (T. rex) skeleton from Montana, that will be transported to the Museum in April 2014. The T.rex is on long-term loan to the Museum from the U. S. Army Corps of Engineers.

We also host a series of temporary exhibits. Most recently, the Museum partnered with National Human Genome Research Institute at the National Institutes of Health (NIH) to create the exhibition, *Genome: Unlocking Life's Code*. The remarkable collaboration between NIH and the Smithsonian marked two important milestones: 60 years since Watson and Crick's discovery of the DNA double-helix and 10 years since the completion of the first human genome sequence. It builds on the strengths of both institutions to engage visitors many aspects of genomics: how genomes impact society, health, and the natural world. An experiential science learning laboratory in the exhibition–the Genome Zone–staffed by trained volunteers, features activities for all ages including opportunities to isolate one's DNA, and engaging sessions with scientists. The exhibition and its engaging education programs continue to be an enormous success, and venues around the country are now being identified to host the exhibit when it closes at the Smithsonian in September.

Through the exceptional content of our educational programs and exhibitions, we are creating experiences for our visitors of all ages. They are experiencing how relevant science is to them and how relevant they are to science.

Last month, we opened *Q?rius* (pronounced "curious"), a new 10,000 square feet learning center. With a name chosen to inspire curiosity and excitement, *Q?rius* is a first-of-its-kind interactive and experimental environment that brings the Museum's science, scientists, and collections onto the floor, and invites visitors to be an active and contributing part of this dynamic and engaging community. The following is a sample of *Q?rius* experiences.

Smithsonian Science Now, is a series of live webcasts that features Smithsonian experts and real-world science. Viewers see how these experts use tools and technology in their work, and

how the science is connected to their lives. Targeted to the classroom, each 25-minute interactive webcast introduces students to core science concepts through the lens of Smithsonian research and experts, providing students with positive STEM role models and a connection to science in their lives. A package of classroom activities, lessons, readings and other related resources will are accessible online, free of charge, to support each webcast program.

Earlier, you had the opportunity to meet Dr. Nick Pyenson and learned how he uses modern digitization techniques to study fossil whales. Imagine a wide-eyed middle school student having a similar experience, able to ask questions and participate in authentic science along with Dr. Pyenson. This Thursday, January 16, students will have that chance when Dr. Pyenson will be the featured expert on a *Smithsonian Science Now* live webcast. I invite you to listen in through the website qrius.si.edu or at Smithsonian Science Now Fossil Whales Webcast. Next month, on Thursday, February 6, Dr. Carla Dove will be the featured expert to discuss her feather identification work to combat aircraft bird strikes. Each month *Smithsonian Science Now* will introduce you to one of the Museum's talented scientists.

Scientist-led programs offer opportunities in *Q?rius* to interact directly with scientists about their specialties, recent discoveries, or a topic in the news. Educator-led programs are facilitated experiences with fragile specimens or advanced topics to which participants can relate.

Since its inception in 2010, the Youth Engagement through Science program (YES!) has connected local youth with Smithsonian collections, experts, and training to inspire them to pursue science, technology, engineering, and mathematics (STEM) careers. The award-winning internship program provides youth from communities traditionally underrepresented in science careers with the resources needed to help them to achieve their ultimate goal of attending college. During six weeks in the summer, YES! students work side-by-side with Smithsonian researchers and educators. In early fall, interns rejoin us for a ten-week college preparatory program.

Self-guided activities are based on or inspired by research that Museum scientists are currently doing. Visitors use scientific equipment, such as microscopes, along with objects and digital resources to participate in solving problems or investigate ways to find answers to their own questions. In the *Reefs Unleashed* activity, for example, teens explore how scientists are inventing new technologies to identify the number and variation of species living in coral reefs, and how DNA analysis reveals lots of new information about previously unknown species.

Partnerships with many world-class science organizations ensure that our visitors encounter educational programs on topics relevant to their daily lives. Several educator positions are jointly funded with other government agencies to promote public learning around ocean science and genomics. These educators create programs, experiences and resources for students, adults and family audiences across the country.

The Museum is a leader in utilizing new technologies to engage the public in science: on-line, and in exhibitions, educational initiatives and programming. As we continue to expand our scientific knowledge, the Museum employs the latest innovations to make our research and collections available to the public.

Strategic Plans and Priority Initiatives

Since 2003, the Museum has engaged in two strategic planning processes: *Understanding Our World (2004 – 2009)* and *Knowledge for a Sustainable Future (2010 – 2015).* These plans set clear priorities, goals and outcomes for the Museum that build on our legacy and help us prepare to meet the challenges of tomorrow and take advantage of future opportunities

In addition to continuing broad explorations of nature and culture, the Museum has committed itself to advancing six priority interdisciplinary initiatives in areas. These initiatives have special relevance and urgency to society, where the Museum has a comparative advantage, and where we are poised to make substantial progress over the next decade. Three of these priorities – the Ocean Initiative, the Human Origins Initiative, and the Encyclopedia of Life – were identified in the 2004–2009 plan and have become reality. The other three – the Global Genome Initiative, Recovering Voices, and Deep Time – were identified in the most recent planning process and are now vibrant functioning programs.

Designed to be long-term and transformational for the Museum, these priorities build on our strengths, integrate our core functions (research, collections stewardship, and outreach), and expand our partnerships within the Smithsonian and with external collaborators. These initiatives and our core work – exploring and interpreting nature and culture – are enabling us to become the hub of a global network of institutions committed to the exchange of ideas and knowledge; advance the application of new methods and technologies to study our collections and share our resources with people across the globe; and play a key role in the training of future generations of scientists and museum professionals. Both of these plans have been made available to subcommittee members and staff. We would welcome your questions or comments.

I have talked about the remarkable collections and the enormous potential they have to help us understand the world in which we live. Our large and capable scientific staff ensures that we will explore the full potential of our collections and tackle emerging research opportunities worldwide. I expressed my belief that our public programs enable us to serve a unique and leading role in advancing science literacy for all Americans. The choices we make today and the direction we take will have a significant impact on future generations. For these reasons and countless others, it is my sincere conviction that the National Museum of Natural History is a unique world treasure, and a continuing source of American pride.

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Dr. Kirk Johnson, Sant Director
Smithsonian's National Museum of Natural History

Kirk Johnson has been the Sant Director of the Smithsonian's National Museum of Natural History since October 2012. At the National Museum of Natural History, Johnson leads a staff of nearly 500 who, each year, host more than 7 million visitors, publish more than 600 scientific papers, and care for 127 million specimens in the world's largest natural history collection.

Johnson is a paleontologist who has led expeditions in 11 countries and 19 states that resulted in the discovery of more than 1,400 fossil sites. His research focuses on fossil plants and the extinction of the dinosaurs. He is known for his scientific books and articles, popular books, museum exhibits, presentations, and collaborations with artists. In 2010-11, he led the *Snowmastodon Project*, the excavation of an amazing ice age site near Snowmass Village, Colorado. This dig recovered more than 5,400 bones of mammoths, mastodons and other ice age animals and was featured in the NOVA documentary, *Ice Age Death Trap*, and in Johnson's book, *Digging Snowmastodon, Discovering an Ice Age World in the Colorado Rockies.*

Before coming to the Smithsonian, Kirk Johnson was vice president and chief curator at the Denver Museum of Nature and Science. At the Denver museum, Johnson oversaw a 70-person research and collections division that included curators, archivists, conservators, and technicians. He was responsible for the museum's 24 collections, and he led the completion of the museum's first comprehensive long-term collections and research plan. He served as a curator of paleontology since joining the Denver Museum of Nature and Science in 1991. As vice president at the Denver museum, Johnson was part of a team that led the museum and managed its $40 million annual budget.

Johnson holds numerous professional memberships, and was recently appointed by the White House Office of Science and Technology Policy to the Interagency Arctic Research Policy Committee. Johnson was also recently elected to National Geographic's Committee for Research and Exploration.

Johnson is originally from Bellevue, Washington, and has a bachelor's degree in geology and fine art from Amherst College, a master's degree in geology and paleobotany from the University of Pennsylvania and a doctorate in geology and paleobotany from Yale University. He did postdoctoral research at the University of South Australia and served as a Crosby lecturer at the Massachusetts Institute of Technology.

Chairman BUCSHON. Thank you for your testimony. I have also watched movies about you guys such as "Night at the Museum."

I would like to remind the Members that the Committee rules limit questioning to five minutes. At this point I will recognize myself for five minutes for questioning. To all witnesses, with regard to scientific research, what does the Smithsonian Institution bring to the table that cannot be achieved by other federal agencies like the National Science Foundation or NASA? Can you describe things that might be unique to the Smithsonian?

Dr. CLOUGH. I will get started. The agencies obviously have different missions, and I served on the National Science Board and was a researcher with NSF funding for many years. We don't fund other groups. We do work with other groups and our collections is one way we would be different from the others. We have the largest scientific collection in the world as Kirk described, and it works a little bit like a national lab the way I see it because it serves as a tremendous research base for all the other scientists to come in and use the collection. We are the caretakers in that way but we use it for our own research as well.

And the interesting thing is collections have become far more important to us in our research endeavors because of genomics and some of the new scientific instruments and tools that we have. So this is sort of a new day if you will for our collection. So our collection is one of those things.

A second way is I mentioned the Forest Global Earth Observatory and the new marine observatories, which Dr. Pell really has made happen. Those are long-term projects. The Smithsonian is very good at collaborating, bringing together teams, and then carrying out work that you can sustain for long periods of time.

We are trusted around the world. I mentioned ForestGEO has over 20 countries involved in it. These are countries that want to share information with us. They trust us as a source of reliable information and they trust us with the data. So I think that the ability to do long-term research, the collections, and the unique capabilities of our scientists are some of the things. My colleagues might want to comment otherwise.

Chairman BUCSHON. Dr. Pell?

Dr. PELL. Well, I would just build on what Wayne talked about because coming from a university where I worked most of my career, you are very much confined as a faculty researcher by the term of your grant. Having the federal appropriation that allows us to establish programs and know will be there in five years, in ten years, in 50 years in 100 years is a huge difference. And as a result, many faculty send their graduate students here and post-docs come here for that experience to work in an environment that has that kind of longevity.

Dr. JOHNSON. And I will just agree with what both of my colleagues said, but just add the fact that we do very basic research on what is on the planet—the life, the rocks, the minerals—and that is a very baseline sort of research that underpins so much more of the innovative and applied research that is out there.

Chairman BUCSHON. And, Dr. Pell, a question about big data. Obviously, we are talking about digitalizing everything and we talk about that a lot. Specifically, how is the Smithsonian handling the

issues of data access, data management, storage, duration, cost control? Because obviously—and Dr. Clough can answer this, too—that is advancing quickly. And how is the Smithsonian trying to address that?

Dr. PELL. That is a huge question and I want Kirk to weigh in as well because we have 137 million objects and we have a mandate to make what we have available to the world. And the best way to do that is through digitization, and so we are on a march to digitize our collections and we are also very much interested in open access at every opportunity that we have. This past year, we had three presidential fellows who came for the very purpose of trying to help us figure out how to do our digitization more rapidly than we had been doing it and we have been taking advantage of crowdsourcing.

And an example I find very intriguing is, as a plant biologist myself, biologists go out in the field and they have field notebooks and they write all this information down, and what you really want to be able to do ultimately is to access those digitally, but you would also love to be able to search them digitally, which is different than just making PDF images of things. And we have started this transcription program for field notebooks and put it out on the web and said anybody interested in—you can bring it up online but it needs to get—it is handwritten and it needs to get digitized. It is remarkable. Am I remembering 1,100 people? Is that the right number of people—from all over have been inputting these data and we have been verifying it and we see ourselves doing more and more of that.

Dr. CLOUGH. I would make one other quick comment. We do deal with the big data and we have a big data challenge. The Smithsonian Astrophysical Observatory is awash in data because they are actively observing the heavens from multiple points of view and retrieving enormous amounts of data. And these we think of as images but it is actually digital information.

The genomics initiatives we have underway are going to generate an additional wave of data. So with Dr. Pell's help, we have been having discussions with Oak Ridge National Laboratory, Department of Energy. They are very interested in what we are doing and obviously they have greater capacity in terms of handling big data than we do and we look to partner with them in the future. They did say they thought we had very interesting problems and I thought that was a compliment.

Chairman BUCSHON. It is. I now recognize the Ranking Member, Mr. Lipinski, for five minutes.

Mr. LIPINSKI. Thank you. I want to go back to something I talked about in my opening statement is STEM education and informal science education. I know a lot of my interest in science came in part from visits to great museums in Chicago like the Museum of Science and Industry and going to Brookfield Zoo. And in fact research has shown that as much as 80 percent of science learning occurs in informal environments like these.

I want to ask Dr. Johnson, putting on your hat as a former chief curator and vice president of the Denver Museum of Nature and Science, can you talk about the challenges faced by museums and science centers across the Nation in terms of availability of funding for developing and maintaining exhibits and educational opportuni-

ties for youth and the public in the communities that they serve, and also talk about how the Smithsonian can be helpful in that regard.

Dr. JOHNSON. That is a very interesting topic. We do know that something like 95 million people a year go to science and technology centers, and it is a very pleasant way to learn very important things. There has been a trend in the last several decades for there to be fewer and fewer scientists at science centers, and as a result, the content isn't necessarily always there. So one of the things the Smithsonian can and is doing is helping to supply science-based content to the museums around the country because it turns out that it is difficult at a certain scale to maintain collections and scientists and still run a viable standalone science center. And what we have seen in many cities across the Nation in the last few decades is the decrease of the health of science in collections at natural history museums and the growth of science centers, which don't have to bear the costs of maintaining collections and scientific researchers.

So this is where being the mothership of the museums allows us to share our resources quite well. We have a product called the Encyclopedia of Life, which is a website that we are building to host literally a page for every species on the planet. And we presently are at 1.34 million pages towards a target of 1.9. So ultimately, I think that the popularity of museums remains high. Funding is challenging, but most of the museums in the country and local markets where the markets realize the value to the education of their youth and families and it is very much my goal as a director of this museum to use the Smithsonian's Natural History Museum to improve the health of natural history museums and science centers across the country. And we are in contact with the Association of Science and Technology Centers to think about how we can bring science back into science centers and support this national endeavor.

Dr. CLOUGH. I will comment on that. This is a very interesting question because at one time you could think of a formal track and an informal track and they did their separate things. I believe that the informal track has shrunk because of the need to meet state standards and so forth, and as a result, there is a gap there for us to fill and that the Smithsonian and other science centers are moving much more closely into the formal education sphere. And we can do that effectively through programs like digital badging where we can give youngsters credentials for completing exercises and proving competency if you will. And so we have about 100 different digital badges now that we offer in different programs that help teachers. We have 2,000 lesson plans available for free to teachers.

Now, in addition to that sort of digital approach, we have a boots-on-the-ground approach in the Smithsonian Science Education Center. I mentioned we are working in three States primarily with Title I students where we work with principals and we work with teachers. We have 600 teachers a year to help them get comfortable in teaching science. We give them curriculum materials. We help the students learn, and we work with the communities to support their schools and to transition through leadership changes with superintendents. So we believe we need to look at it

not just from the point of view digital delivery but also boots-on-the-ground and hard-core being in that space. We are just starting up a big program in Denver in the same way.

Mr. LIPINSKI. In the little time I have left I wanted to go a little more into the issue of the provision in 2010 COMPETES reauthorization that required OSTP to develop consistent policies for the management and disposal of federal scientific collections and develop an online clearinghouse for information on federal scientific collections. You talked a little bit about this already, but how are you working to achieve this and what kind of collaborations do you have with federal agencies with large collections? You talked about general questions with big data and where to store this, but can you provide further comments on how this process is coming along?

Dr. PELL. Well, I would want to mention that we co-chair with the USDA the interagency working group on scientific collections because I think across the government we are recognized as probably having the largest collection, so we are working with them on all of the standards. And Scott Miller is sitting behind me and is the Deputy Under Secretary for Collections and he is the co-chair of that committee. I would also say that we work very closely every day with a number of the agencies that have large collections. USDA, Park Service, and Department of Interior all have collections and staff that live at the National Museum of Natural History, so there is a very close collaboration on a daily basis as well.

Mr. LIPINSKI. All right. I see my time is up. I will yield back. Thank you.

Chairman BUCSHON. Thank you very much.

I now recognize Mr. Massie, five minutes.

Mr. MASSIE. Thank you, Mr. Chairman.

I see some nice it looks like 3–D models up there that come from some of the artifacts that were scanned I presume. One question that I have is do you allow public use of all of your 3–D models? Can people who have a 3–D printer go and get these models and what sort of efforts do you have to promote those 3–D models if so?

Dr. CLOUGH. Well, we think 3–D models have a great future, 3–D imaging and 3–D files if you will, because it gives people access to our collections in ways they never had before. It may not be exactly the real thing but it sure looks like the real thing in many cases. So we have developed a three-dimensional imaging group and we think it is the leading group in the world. We just had an international conference where hundreds of people came to the conference. We rolled out, in essence, our first collection of images that are fully 3–D ranging all the way from a ship, the Gunboat Philadelphia in American history, down to a bee to show the possible—as well as—I guess the big one was the—we had a galaxy collapsing also that we imaged. But the idea was to illustrate the range of things we can do. That is accessible on our website. It is 20 objects. You can download the files themselves. You can manipulate them when you are there. You can look at them in different colors. And what we learned from that exercise was many scholars are astounded because they can see things on objects they have never seen before. These can be downloaded by a teacher in schools in your community if they have access to a 3D printer. Some of these printers get to be very cheap now. They can print out the ob-

jects themselves. If they don't have access to a printer, there are internet sites now where you send these files to a company and they will print it out for you.

Mr. MASSIE. All right. Are there any——

Dr. CLOUGH. So we are making this available for free.

Mr. MASSIE. Are there any restrictions on the use of those——

Dr. CLOUGH. No.

Mr. MASSIE. —data?

Dr. CLOUGH. None whatsoever.

Mr. MASSIE. So they can show up in a movie and be used there as well?

Dr. CLOUGH. Presumably. We have to be a little careful.

Mr. MASSIE. Okay.

Dr. CLOUGH. I will say that, as I showed several Members of the Committee, we had this conference and they had demonstration technology there, one piece of which was they would take an image of anything within this cage, which happened to be, in one instance, me. And so I was imaged and the next day they presented me with a seven-inch-high model of myself, which my wife says is weird.

Mr. MASSIE. Yes. I have got another question while we are talking about archiving into shapes. You know, it used to be popular to go out and shoot rare animals and stuff them. Is there any sort of contemporary version of that where we are cataloging DNA of existing species, for instance?

Dr. JOHNSON. Yes. One of the things we have realized is that every organism has an amazing amount of information in its genetic code, so every single organism is a unique example of life on the planet. And the best way to preserve that is to freeze it at very cold temperatures. And we have built in Suitland, Maryland, a frozen repository with 5 million slots. We use both nitrogen and deep cold freezers to preserve tissue samples of objects that we have the body of the object in the museum. So we have both the actual physical entity and the frozen tissue from which we can extract genetic information and genomic information. So we are realizing that a museum of the 21st century preserves both the body and the genetic components.

Mr. MASSIE. Along those lines, I think in other countries there is an effort to archive seeds sort of to preserve at least the genetic diversity that we have among our agricultural crops and the opportunities to grow that. And those are always at risk because these things propagate on their own through pollen and through the wind. Do we have any sort of seed archive at the Smithsonian?

Dr. JOHNSON. Yes. We do not have a seed bank. We do keep a number of animal gametes at the Smithsonian Conservation Biology Institute so the fertile parts of rare and endangered species that we are breeding right now, we keep their gametes frozen. So that is effectively the seed of the animal if you will. And we are breeding things like cheetahs and black-footed ferrets and maned wolves. So rare and endangered animals, we will preserve their reproductive output.

Mr. MASSIE. Great. I just have one other question on climate change. What percent of your budget is devoted to studying climate change or archiving that in sort of the contemporary debate right

now over whether man is having an effect on that and to what degree?

Dr. CLOUGH. I don't think we know the percentage as you describe it. The Smithsonian does a lot of research that relates to climate change. It is not directly focused on that. For example, we study bird migration patterns at the National Zoo. We know that bird migration patterns are changing because the climate is changing, but we have studied bird migration patterns and birds for other reasons than just that. There are many areas where we are actually doing work that relates to and illustrates climate change. We look at the acidification of oceans because we study reefs, and acidification of oceans affects reefs and it has something to do with the chemicals of the greenhouse gases that are in the atmosphere. So we do a lot of work that touches on climate change but is not necessarily directed at the singular issue by itself.

Mr. MASSIE. Thank you very much. My time is expired.

Chairman BUCSHON. I now recognize Ms. Kelly for her questions.

Ms. KELLY. Thank you, Mr. Chair, and thank you for being here.

Under your leadership, Dr. Clough, the Smithsonian named Claudine Brown as its first Director of Education, now the Assistant Secretary for Education and Access. We have all heard the latest statistics from the Program for International Student Assessment finding that American students are lagging further and further behind their international counterparts in math and science, scoring average to below average in the subjects. Unfortunately, these scores are even lower on average for minority students in communities with limited access to the kinds of advanced technology found in many higher achieving school districts and classrooms. Can you talk more about your efforts to broaden participation? And beyond counting the number of students your programs touch, how do you measure the impact on the students who go through these programs?

Dr. CLOUGH. That is an excellent question. Dr. Brown has been essential to the work that we have been doing. We didn't have that position before. And many of our museums, as Kirk described, have wonderful education programs but we wanted to coordinate them and use them in some capacity so more people can access the broadness and pick and choose what they need. What we have learned from teachers, for example, is they don't want our lesson plans per se. They would prefer us to provide them with a framework in which they can fill in and paint the palette, if you will, for their local communities, and so we have tried to work with them on that kind of concept.

I think what we have tried to do is to take the multiple approach of there are places where boots on the ground are essential and we can help teachers teach science better. But many teachers, as you know, are not necessarily credentialed in science, and so we try to help teachers get over that hump of being afraid of the subject that they have to teach. They have no choice but to teach it. So we have worked at this now for 20 years and we have gotten very good at it.

Claudine's group also is working very closely with our affiliate museums to give them options for access to our materials. For example, in the sciences we have about 50 of our affiliates—and the

Burke Museum of Natural History and Culture in Seattle, Washington just signed up, as a matter of fact, as one of our affiliates—that are science museums, or research centers. So recently, we got a grant from the Gates Foundation and we created an option for our students to go to the Smithsonian Astrophysical Observatory and use their telescope and talk to our scientists and to their educators and learn about the universe by actually talking to experts. So active learning, we think, is a real key to what to do.

We are also very grateful to the Gates Foundation for having given us a $30 million grant for an endowment called Reaching New Audiences. It is a competitive grant process, and all of our museums apply and they have to come up with really good ideas to reach audiences we traditionally have not reached very well. And that is now in its third year. We have now given out $5 million. It is an endowment that we spend to reach new audiences and we are really learning a lot about that. And educators from NSF and others now are joining us in these efforts. It is a collaborative effort and it is exciting what we are seeing.

Ms. KELLY. Wow, that is fantastic. Also you mentioned in your testimony that the Smithsonian Science Education Center launched its new Workforce Development Initiative. And I am just curious, why is that under the scope of the Smithsonian to concentrate on workforce issues and how does that fit with your mission?

Dr. CLOUGH. Well, there has been an interesting thing because I came out of the university world and I was used to a little more traditional age group in terms of the group you are targeting for education. The Smithsonian, we like to say, starts with 2-year-olds and goes to 92-year-olds. So we have a lot of experience in educating people who are nontraditional learners, who are lifelong learners, who are curiosity-based liners, and adult learners. And we like to work with families, if we can because that is also very helpful as well. But we are learning from the Department of Labor, and from the Department of Commerce. We work closely with the Patent Trademark Office in the Department of Commerce—there is a big gap in terms of workforce training. We won't do all of that but there are places where our digital badging program will be perfect for some of the material that we teach to late-grade students and others to help people get literacy and understand what they need for scientific literacy to do their work.

Ms. KELLY. Thank you. I yield back.

Chairman BUCSHON. Thank you very much.

I now recognize Mr. Hultgren, five minutes.

Mr. HULTGREN. Thank you, Mr. Chairman. Thank you all so much for being here. Thank you for your great work.

I do think it is so important for us as a Committee and as Members of Congress to be having this conversation, and I believe so strongly in our museums. We had a very interesting hearing last week about STEM education and specifically how do we inspire young people to get engaged in science and technology and engineering and mathematics, a very good hearing but so much more work that we need to do.

One of the things that really does bring us together as Members of the House and Senate, Republicans and Democrats, is a need in

our Nation to be recommitted to STEM education. And I see museums as a key part of that. So thank you for your work.

I also want to say I thank you for your recognition of the young man Jack Andraka who invented the pancreatic cancer test strip. I got to meet him at Ideas Week in Chicago a year ago, so impressive, so energetic. But that is what it is all about is getting young people excited and seeing that there is no barriers really at that age to have a passion and pursue it. And that is what is so exciting to me. So thank you. Thank you for your work. This is so important for us to discuss this so that we can prioritize with limited resources, prioritize funding and also make sure that we are not wasting and doing duplicative type programs.

I do want to focus a little bit on something that does concern me a little bit or I have heard some concern for some of my local museums. When the Administration decided to reorganize how STEM education was handled at the federal level, there were many in the stakeholder community who seemed taken by surprise with the proposal that they were not consulted about.

Dr. Clough, I wonder, the President's Fiscal Year 2014 budget included an additional $25 million for the Smithsonian to become the lead agency for informed—to inform STEM education. Many in the informal education community that I have been in touch with in Illinois are concerned about this, especially since your organization cannot make external grants. I wondered what role you played in developing this new role for the Smithsonian, how you have responded to concerns from the STEM education community, and what I can take back to my local institutions?

Dr. CLOUGH. We did not have any role in formulating the plan. We heard about it rather late in the process, unlike most. Basically, when we got our passback we learned that there was an effort to do this. Obviously, we had concerns ourselves when we first heard about it because many of the agencies that were going to lose some of their capacity, we work with them. And in some cases they fund us. And so, in the Air and Space Museum we work with NASA in space education and HIH and so forth. So we wanted to talk to our friends and try to understand what we could do, and if the plan were to go through, we wanted to make it one where we helped them in any way.

We felt, for example, if we were going to go through with this, that maybe two or three NASA educators will come to the museum and in essence be surrogates for NASA in our programs so they could help make sure we were doing the right thing on their behalf. I think what we learned out of this and the whole effort eventually moved on, but we had a number of meetings that were very useful. It was an odd sort of process and it happened rather quickly, but it really brought all of us together in the STEM education field and we started talking and we found out places where we were doing things that others weren't doing and places where others were doing things we weren't doing and we created some really remarkable new collaborations out of that.

For example, I mentioned digital badging. It happened to be something that we have been very aggressive about with funding from the MacArthur foundation, and so we were able to share what we were doing in digital badging and now we have little groups

coming together to talk about digital badging where we are sharing our insights about that. And so in a way it had this odd sort of positive benefit at the end of the day.

Now, as far as the other museums are concerned, obviously, we are the Nation's museum and we try to make a point about that. That is why we have 184 affiliate museums. So we have museums all over the country, many of which happen to be science museums. And we share everything we have. Our goal is, as soon as we do something, share it. As I mentioned with Colorful Cosmos was an unusual case where we did issue a sub-awards. We used the Gates Foundation money that I mentioned earlier and we provided that to the regional museums that didn't have a lot of money. We would award them $2,500 so they could advertise it thoroughly through their local schools and get as many young people as possible engaged in this great opportunity to work with our scientists at SAO. So we try to work very collaboratively with everyone wherever we go.

Mr. HULTGREN. Let me follow up on this real quick. My understanding is you can't make external grants specifically with your resources that you have been given. How is the institution able to partner with private sector organizations? You have talked to about a little bit, I guess, with the Gates but also just—if you can further on that a little bit more of any other STEM education-related research or programs that you see moving forward again that could provide hope and encouragement? Maybe that has already been presented to a lot of these institutions, but I have heard some concern I know from some great institutions in the Chicago area.

Dr. CLOUGH. A good example of that was the innovation grant from the Department of Education. It is very competitive to get in the game and we were, because of our experience, chosen to go forward with that effort. The Department of Education gave us $25 million but we had to raise $8 million privately. And the idea is to engage the corporate community in the project so they get, if you will, skin in the game in their schools and so we leverage federal dollars with private dollars to make this work.

I mentioned we are in Denver and it partly started when Kirk was still out in Denver and we visited out there. We have four affiliates in the Denver area of our museum. We worked very collaboratively with those four museums. The Science and Nature Museum is one of those. That effort is being entirely funded by the corporate community because they love what we are doing in our laser program, the one I mentioned, and they are more than willing to fund us to do this. And so in that case it happens to be almost a totally privately funded effort but we are doing it in total collaboration with the local museums. In fact, the head of the Denver Museum is our champion in Denver to get that done.

Mr. HULTGREN. My time is past expired. Thank you very much. I appreciate it and yield back, Chairman.

Chairman BUCSHON. Thank you very much.

I recognize Mr. Collins, five minutes.

Mr. COLLINS. Thank you, Mr. Chairman.

You know, I love your museums. I used to come down here in another life and I would always come down the night before and pick one of your museums to go to. So I am going to ask you a tough

question so I want to set the stage. I love museums. I love what you do. I am a collector of a number of things. And so here is my question. When I was the county executive of Erie County, New York, largest upstate county. If you know our history, 1901 Pan Am Exposition, one of the wealthiest cities in the United States at the turn of the last century, now the third-poorest in the United States, but because of that history, we have one of the most magnificent science museums, one of the first in the country. We have a wonderful historical society. We have got one of the greatest rare books collections anywhere in the world. And, Dr. Johnson, we are home to the Penn Dixie paleontology site. I don't know if you visit us but that is well known.

So here is my issue. As county executive, we provided millions of dollars of funding to each of these institutions, and I remember a tour of the science museum and they display about two percent of what they have. When I went into one room, honest to God, they had 1,000 spears, from hundreds of years ago and 10,000 arrowheads. And I am pragmatic to a fault. I know I am. It is dollars and cents. But in this day, as Dr. Johnson said, funding for these museums is difficult, especially at the community level. What is your opinion of deaccessions and if I have got 10,000 arrowheads and I got to store them, selling 8,000 of them and—you know, you could raise big—I am not talking about selling the Hope Diamond although I would wonder what that might bring. It might dent our national debt.

But could you just, you know, for a local museum and local people, no one ever wants to give anything back, but let's face it, many of them have so much stuff they have got to pay and—just kind of interested in your opinion, not at your level but more at the local level?

Dr. JOHNSON. Yes. I think one of the important things to think about collections are many things and many of them formed in the late 1800s or early 1900s and we have got a lot of legacy collections out there. Museums that are well run do a fair amount of collections planning and collections improvement, and improvement includes both adding things to the collection but also removing things from the collections that are no longer useful or needed. It is a tricky business, and in some cases, things like rare and endangered species or Native American artifacts, it is very difficult to ethically dispose of them. So you might think this is no longer needed but what is the right step to deaccession it and then remove it to a different place ethically? Often, we find it takes more money to deaccession something than is available. So it is not a simple solution. There have been many museums who thought they could get out of the business of being museums and find that it actually costs more to get out of the business than it does to stay in the business.

So it is a challenge but there has been a growing trend and we are one of the leaders in the trend of careful collections planning with the intent of collections improvement because collections must be used to be housed in the collections arena. And we have done a lot of good work with that here because it is not just the condition of the collection; it is what their intellectual value is. Is it something that we need to keep? Is there a reason for society to

keep these objects in the public trust? So a very hot topic in museology right now.

Dr. PELL. I will just add to that. You are talking about arrowheads, which are pretty small. Well, we have some very large things in our collection, too. We have aircraft, many of them, and storing them is a huge challenge for us. And General Dailey, who is the Director of the Air and Space Museum is very carefully and from time to time deaccessioning some of our aircraft to other aircraft museums around the country. So there are times when it is appropriate to deaccession, especially if we know that we can then make that artifact more available to more people.

Dr. CLOUGH. I would just add one more thing to this. The opportune time to really make decisions about some of these things is when you are doing some major overhaul to a collection center. And we have military history uniforms at the Smithsonian in the American History Museum, and recently, we were fortunate to really go after that collection center and update it and upgrade it. And it turned out we had many duplicates of those uniforms and there was no reason for us to have those. And as you know, there are many military museums around the country. And so we deaccession by giving them to other museums that had a case for those objects.

Mr. COLLINS. Well, I appreciate that. I can tell you when I mentioned that at a board meeting, there was a hush in the room that is even hard to describe when I thought of doing it, not to give it to another museum but to sell it for money to help fund the operations. It didn't go over real well. But, in this day and age you have got to consider things. And as you said, whether it is uniforms or other objects, there is a value there and so forth.

Well, again, my time is expired but thank you for letting us enjoy your exhibits today, and again, I am a big fan of yours and thank you for all you do.

Dr. JOHNSON. Thank you.

Chairman BUCSHON. Well, thank you very much to all the witnesses. It has been fascinating testimony. Thanks for bringing the scientists, for bringing all of your objects from the Smithsonian. We have a nice military museum, by the way, in Vincennes, Indiana, and a private guy would appreciate a few planes if you are getting rid of any of them. This is a guy who actually started a collection when he was in high school and now he is probably in his late 60s; over the years he has collected—and he of course travels the country meeting all kinds of people and people give him planes because they know him. It is fascinating.

The record will remain open for two weeks for additional comments and written questions from the Members. At this point the witnesses are excused and the hearing is adjourned.

[Whereupon, at 3:30 p.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. G. Wayne Clough

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

"Science at the Smithsonian: More than a Museum"

Response to Question for the Record, Dr. G. Wayne Clough, Secretary, Smithsonian Institution

Questions submitted by Rep. Larry Bucshon, Chairman, Subcommittee on Research and Technology

On January 10, 2014, the Washington Post ran an article entitled "Historic Warship in Middle of a Budget Battle," that reported that a private Virginia museum cited lack of federal funds in closing the lab that stores USS Monitor artifacts. In addition, it stated that "the National Oceanic and Atmospheric Administration (NOAA), which has a Monitor Partnership with the museum, provided 10 percent of conservation costs last year." Were you aware of this partnership and did the Smithsonian contribute any technical help? Did you ever coordinate with NOAA about this research? Do you think the Smithsonian, rather than NOAA, should have a major role in the ship's future conservation? If the museum and laboratory closes, will the Smithsonian be playing any role in its future preservation?

Dr. Clough: The National Museum of American History (NMAH) was aware of the partnership and had a limited consulting role in the establishment of the Monitor National Marine Sanctuary in 1975. NMAH also was part of the advisory process that led to the decision that the Mariners' Museum would be a suitable location for the objects recovered from the Sanctuary. NMAH has not been involved in recent years in any of the work on recovering or conserving the artifacts.

Institutions focused on naval history would seem to be appropriate partners for managing the large artifacts recovered from the sanctuary. However, if asked, NMAH is prepared to provide consultation to the project in the future, as it has done in the past.

Responses by Dr. Eva J. Pell

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

"Science at the Smithsonian: More than a Museum"

Response to Question for the Record, Dr. Eva J. Pell, Under Secretary for Science, Smithsonian Institution

Questions submitted by Rep. Larry Bucshon, Chairman, Subcommittee on Research and Technology

How does the Smithsonian make research decisions? In other words, how do you prioritize research and determine which activities and disciplines on which to focus, particularly when your scientists are full-time employees whose disciplines or areas of research do not change?

Dr. Pell: The Smithsonian Institution is guided by its strategic plan which identifies four "Grand Challenges" that provide an overarching strategic framework for Smithsonian programs and operations. Two of the challenges – Understanding and Sustaining a Biodiverse Planet and Unlocking the Mysteries of the Universe – concentrate on science and serve as the principal areas of focus for our research.

Each museum and research institute has a focused strategic plan. For example, the National Zoo's (NZP) research program has fostering conservation as a primary research goal; the National Museum of Natural History (NMNH) works to understand species diversity through the use of genomics; and both the Smithsonian Tropical Research Institute (STRI) and the Smithsonian Environmental Research Center (SERC) have global earth observations – forest and marine –as one of their strategic goals. The National Air and Space Museum (NASM) studies earth planetary systems and the Smithsonian Astrophysics Observatory (SAO) develops the instruments used in studies to explain the origins of the Universe and its stars and planets and in the quest for identifying habitable planets. Each unit has a number of goals along these lines.

The Smithsonian strategic plan calls for collaboration both within and external to the institution. In fact, a number of initiatives are driven by collaborations across the units. For example, the Global Earth Observation programs afford significant collaboration opportunities as scientists from NMNH, NZP, SERC and STRI interact and work with colleagues throughout the world.

It is important to note that the Smithsonian collections provide the foundation for much of the scientific research conducted here. Research often builds on these collections. Currently, scientists at the NZP and the NMNH are working together to determine the cause of the threatened extinction of the Tasmanian Devil. By studying specimens in the NMNH collection which were preserved 100 years ago when an animal died at the NZP, scientists using the tools of ancient DNA analysis can determine why these animals died and relate that to contemporary disease threats to this species.

Priority is given to research that supports the strategic plans of the Institution and the unit; for research that is collaborative; and for research that builds upon our collections. When those parameters are satisfied, Smithsonian must make smart resource allocation choices in determining what research is conducted. Many of our scientists have federally funded salaries, and Smithsonian often seeks additional funding for research projects from agencies such as NASA and NIH as well as from private foundations. The parameters set by a solicitation for grant proposals can influence the direction of research, but the proposals submitted by our scientists are framed within the basic priorities of the Institution.

Responses by Dr. Kirk Johnson

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

"Science at the Smithsonian: More than a Museum"

Response to Question for the Record, Dr. Kirk Johnson, Director, National Museum of Natural History

Question submitted by Rep. Elizabeth H. Esty

You testified that researchers at the National Museum of Natural History have been working to prevent tragedies – such as the one that almost occurred when US Airways flight 1549 crashed into the Hudson – by providing data to engine manufacturers like Pratt and Whitney so that they can build smarter engines that are better equipped to combat these hazards.

As someone who has always been a strong champion of basic research I appreciate your brief testimony about the importance of basic research in informing private industry so that they can build smarter and safer equipment. Could you – or one of your colleagues on the panel – elaborate on why research conducted at institutions such as the Smithsonian is vital to our country's economic growth?

Dr. Johnson: The Smithsonian Institution is a trust instrumentality of the United States that was established for the "increase and diffusion of knowledge." In terms of Smithsonian science, this means a focus on basic research. Smithsonian scientists work to document, understand and conserve new and existing species, monitor our changing world, and discover new planets. This information is made available freely to the general public, including private industry.

There have been several cases in which Smithsonian research or expertise has had a positive economic impact. These impacts, however, are a byproduct of the basic research that is undertaken across the Institution. Here are several examples -

As mentioned, the work of the National Feather Identification Laboratory at the National Museum of Natural History (NMNH) has been used by the Department of Defense and the airline industry to improve safety and prevent loss of both life and airplanes . For more than 50 years researchers at NMNH have been working behind the scenes to provide data to the Federal Aviation Administration (FAA), the U.S. Air Force and Navy, and to engine manufacturers such as General Electric and Pratt & Whitney, regarding the species identifications and weights of birds that are struck by aircraft. Knowing the natural history of problematic species will help reduce the damaging costs of bird-strikes on airfield environments and improve aviation safety.

NMNH scientists also partner with staff based at the museum from the U.S. Department of Agriculture and NOAA's National Marine Fisheries Service to identify invasive agricultural pests and focus on commercially important fishes, respectively.

The Smithsonian Environmental Research Center (SERC) in Maryland partners with the United States Coast Guard in the National Ballast Information Clearinghouse (NBIC) program. NBIC collects, analyzes, and interprets data on the ballast water management practices of commercial ships that operate in the waters of the United States. A principal aim of NBIC is to reduce the likelihood of ballast-mediated invasions by exotic species which can have significant economic impact.

Appendix II

Additional Material for the Record

SUBMITTED STATEMENT OF REPRESENTATIVE EDDIE BERNICE JOHNSON, RANKING MEMBER, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Good afternoon, I would like to thank the Chairman for holding today's hearing to explore the scientific research the Smithsonian is undertaking.

The Smithsonian was established from a bequest of more than $500,000 from a British scientist who never set foot on American soil. While he never wrote about his motivation of giving the money to the US, some speculate that he was inspired by the United States' experiment with democracy, as well as his own philanthropic ideals. He gave this gift to found an institution for the "increase and diffusion of knowledge." From that initial gift over 160 years ago, this country has continued to fund the Smithsonian which has become as much of a national treasure as any other monument on the National Mall.

It is easy to see how kids can be inspired to run home and look for fossils in their backyards or try to identity the constellations in the night sky after walking through the halls of any one of the Smithsonian's museums. We only have to look at the latest student assessment statistics to understand that our students are falling further behind their international counterparts in science and math. American competitiveness depends on our students' ability to meet the science and technology needs of the not so distant future. The Smithsonian's role in informal education is one that very much gives students a hands-on experience for those subjects they learn in their classrooms, enhancing their overall learning experience. Making STEM education a positive learning experience is very important, and making more STEM education programs accessible in communities that are underrepresented in the STEM career fields is essential for our nation's competitiveness.

I am eager to hear the status of the Smithsonian's role as the lead agency on informal education and outreach as outlined in the Administration's fiscal year 2014 proposed STEM education reorganization.

In addition to the Smithsonian's administration of STEM programs, it leads large-scale, worldwide research and curates and manages scientific collections used not only by Smithsonian scientists but also federal agencies. I congratulate Dr. Clough and Dr. Pell on their work, and wish them well as they move on to future endeavors. I look forward to a smooth transition in leadership and continuation of the important research and education work done at the Smithsonian.

Again, I thank the witnesses for being here today and look forward to their testimony. I yield the balance of my time.